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NAVY COMMUNITY OF PRACTICE FOR PROGRAMMERS AND DEVELOPERS

by

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December 2016

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The Navy must employ the talented programmers and developers required to build and maintain its software systems. The establishment of a Navy community of practice (CoP) for programmers and developers can significantly increase knowledge sharing, provide mentorship opportunities, increase cybersecurity of computer-dependent systems, and expose the Navy and industry to each other's cybersecurity needs and requirements, as well as best practices, tools, and techniques. The design for a Navy CoP should be human centered and should reflect the key characteristics shared among successful communities of practice. Through the use of surveys, interviews, and observations conducted at the June 2016 HACKtheSKY Navy hackathon, it was discovered that there is a need and want for such a Navy CoP. CoP design and specific Tenth Fleet recommendations were drafted with focus on social interactions, operational structure, and lifecycle characteristics. In conclusion, there is high confidence that the Navy will benefit long term from expanding its boundaries in the cyber domain and practice of programming and development.

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NAVY COMMUNITY OF PRACTICE FOR PROGRAMMERS AND DEVELOPERS

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ABSTRACT

The Navy must employ the talented programmers and developers required to build and maintain its software systems. The establishment of a Navy community of practice (CoP) for programmers and developers can significantly increase knowledge sharing, provide mentorship opportunities, increase cybersecurity of computer-dependent systems, and expose the Navy and industry to each other's cybersecurity needs and requirements, as well as best practices, tools, and techniques. The design for a Navy CoP should be human centered and should reflect the key characteristics shared among successful communities of practice. Through the use of surveys, interviews, and observations conducted at the June 2016 HACKtheSKY Navy hackathon, it was discovered that there is a need and want for such a Navy CoP. CoP design and specific Tenth Fleet recommendations were drafted with focus on social interactions, operational structure, and lifecycle characteristics. In conclusion, there is high confidence that the Navy will benefit long term from expanding its boundaries in the cyber domain and practice of programming and development.

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LIST OF ACRONYMS AND ABBREVIATIONS

APAN	All Partners Access Network
CC	Company Command
CCW	Center for Cyber Warfare
CNO	Chief of Naval Operations
CoP	Community of Practice
CoPs	Communities of Practice
CTF	Commander Task Force
CWE	Cyber Warfare Engineer
DOD	Department of Defense
IO	Information Operations
JIFX	Joint Interagency Field Experimentation
JTF-DODIN	Joint Task Force Department of Defense Information Networks
MCPA	Military Cyber Professionals Association
MCSC	Marine Corps Systems Command
MMOWGLI	Massive Multiplayer Online Wargame Leveraging the Internet
NAVAIR	Naval Air Systems Command
NAVFAC	Naval Facilities Engineering Command
NAVIFOR	Naval Information Forces
NAVSEA	Naval Sea Systems Command
NAVSUP	Naval Supply Systems Command
NPS	Naval Postgraduate School
OPNAV N2/N6	Deputy Chief of Naval Operations for Information Dominance/Director of Naval Intelligence
RUX	Rapid User Experience
SECDEF	Secretary of Defense
SPAWAR	Space and Naval Warfare Systems Command
SYSCOMS	System Commands

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I. INTRODUCTION AND BACKGROUND

Communities of Practice (CoPs) are groups of individuals who learn and perform better through interaction as a result of a shared passion or concern [1]. Through social networking, sharing knowledge, and collaboration, members of CoPs often outperform the average individual performing the same job assignment [2]. This thesis makes the assumption that the Navy would benefit from designing a community of practice (CoP) for Navy programmers and developers, in order to strengthen the cyber workforce and support Navy cyber missions and objectives. Fostering a CoP specific to the practices of programmers and developers may enhance cyber mission success.

This research focuses on the potential benefits gained from designing a CoP for programmers and developers, and a methodology to cultivate such a community in the Navy. The term programmer refers to individuals engaged in both software and firmware programming activities. The term developer refers to individuals' engaged in a system's lifecycle that involves code. Additionally, the term Navy programmers and developers is not exclusive to Navy individuals performing these duties in an official capacity, but it also extends to all Navy individuals who engage in these practices in an unofficial capacity or as a hobby. This chapter introduces the stimulus for this thesis and the structure of the Navy cyber community. It also outlines the research scope and methodology, and summarizes the primary research questions. The benefits from this study follow in turn, and the last section outlines how this research is organized.

A. TODAY'S NAVY CYBER COMMUNITY

U.S. Fleet Cyber Command/U.S. Tenth Fleet is the Navy's "authority for cyberspace operations, as well as the operational authority and capability provider for Information Operations and cyberspace operations" [3]. As Commander, Fleet Cyber Command, they operate as the Navy component commander to U.S. Cyber Command. As Commander, U.S. Tenth Fleet, they direct naval operations including: network operations and defense, information operations, service cryptologic component operations, fleet and theater operations, and research and development [3]. The vision of Fleet Cyber

Command is to "conduct operations in and through cyberspace, the electromagnetic spectrum, and space to ensure Navy and Joint/Coalition freedom of action and decision superiority while denying the same to our adversaries" [3]. The Fleet Cyber Command's and Tenth Fleet mission statements amplify their goals and objectives:

> The mission of Fleet Cyber Command is to serve as central operational authority for networks, cryptologic/signals intelligence, information operations, cyber, electronic warfare, and space capabilities in support of forces afloat and ashore; to direct Navy cyberspace operations globally to deter and defeat aggression and to ensure freedom of action to achieve military objectives in and through cyberspace; to organize and direct Navy cryptologic operations worldwide and support information operations and space planning and operations, as directed; to execute cyber missions as directed; to direct, operate, maintain, secure, and defend the Navy's portion of the Department of Defense Information Networks (DODIN); to deliver integrated cyber, information operations, cryptologic, and space capabilities; to deliver a global Navy cyber common operational picture; to develop, coordinate, assess, and prioritize Navy cyber, cryptologic/signals intelligence, space, information operations, and electronic warfare requirements; to assess Navy cyber readiness; and to exercise administrative and operational control of assigned forces.
>
> The mission of Tenth fleet is to serve as the Numbered Fleet for Fleet Cyber Command and exercise operational control of assigned Naval forces; to coordinate with other naval, coalition and Joint Task Forces to execute the full spectrum of cyber, electronic warfare, information operations and signal intelligence capabilities and missions across the cyber, electromagnetic and space domains. [3]

The mission statements discuss Fleet Cyber Command and Tenth Fleet operational areas. The mission statements do not state who is tasked with completing the mission. Therefore, it is important to define which personnel carry out these operations.

Within the Navy, there is an undefined formal and an informal cyber workforce. This thesis defines the term "formal cyber workforce" to include all personnel (Navy Officers, Navy Enlisted, Navy Civilians, and Navy Contractors) who work in billets associated with cyberspace operations. In most instances the formal cyber workforce is involved in completing the tasks outlined in the mission statements above. However, the mission statement of Fleet Cyber Command does not encompass the full spectrum of cyber risks the Navy faces. For example, Navy platform information technology such as

industrial control systems, aviation mission computers, and weapon systems are not in the Fleet Cyber Command mandate, but are essential to Navy operations. The uniformed and civilian workforce that deals with these systems, from design to operation, are an important informal component of the Navy cyber workforce. Therefore, we also define the term, "informal cyber workforce" to include all personnel (Navy Officers, Navy Enlisted, Navy Civilians, and Navy Contractors) not serving in a cyberspace operations billet, but performing duties associated with that of a programmer or developer delivering computer dependent capability to the Fleet.

Defining the formal and informal cyber workforces is important to this thesis, because we make the assumption that greater collaboration between the two workforces will enhance the execution of Fleet Cyber Command's specific missions, and strengthen the ability to defend cyber systems outside the limited Fleet Cyber Command mandate.

B. SCOPE AND METHODOLOGY

The thesis focuses on the potential benefits to be gained by establishing a Navy CoP for programmers and developers that bridges the formal and informal cyber workforces. However, the scope of this thesis also includes the way the Navy engages with industry partners.

A broadened scope that includes industry partnerships is necessary because a Navy CoP with a purely inward looking focus would prevent knowledge diffusion and mentorship opportunities that may enhance the Navy's capability to execute cyber missions.

The methodology employed in this research is human-centered design via a social interaction prototype, which allows us to learn and summarize the needs of individuals in order to design an efficient and sustainable CoP for Navy programmers and developers.

C. RESEARCH QUESTIONS

The primary research question explored in this thesis is:

- How might the Navy benefit from a Navy CoP for programmers and developers?

Secondary questions explored in this thesis include:

- What are CoPs and why are they important?
- What are key characteristics of successful CoPs?
- What successful communities exist within the military? What successful communities external to the military, are used by military organizations?
- Who might be sponsors, champions, and stakeholders for a Navy CoP for programmers and developers?
- What are design, design thinking, and human-centered design?
- How might the Navy design a CoP for programmers and developers that incorporate key characteristics shared by existing successful communities?
- What design method might be utilized to design a CoP?
- What additional research or prototyping might help the Navy further the design and sustainment of a Navy CoP for programmers and developers?

D. BENEFITS OF STUDY

Organizations that have instituted well-designed and effective CoPs have experienced many benefits, including improved collaboration, implementation of a shared framework, improved dialogue, stimulated learning, captured and diffused knowledge, improved organizational skills, and the generation of enhanced knowledge [4]. These benefits are highlighted as part of the value proposition for a Navy CoP for programmers and developers. The result of this research adds to our understanding of how to design a CoP using key characteristics shared among successful communities.

Furthermore, this thesis provides Tenth Fleet with recommendations to design a Navy CoP for programmers and developers in order to make the Navy more combat effective.

E. ORGANIZATION OF STUDY

Chapter II introduces fundamental concepts, theories, and practices of CoPs to better understand benefits gained from community engagement across an organization. It also introduces common terms used throughout the thesis. Finally, it makes a case for why the Navy needs a CoP for programmers and developers.

Chapter III identifies key characteristics of CoPs in existing literature and correlates them to existing successful communities and tools that the military engages with or utilizes.

Chapter IV introduces the ideas of design, design thinking, and human-centered design. Then we apply these methods to design a CoP for Navy programmers and developers.

Chapter V details the methodology used to design the proposed CoP. This chapter summarizes the results from surveys, interviews, and observations conducted during a three-day event, HACKtheSKY. This chapter also outlines proposed sponsorship for a future Navy CoP for programmers and developers. It concludes with recommendations and a series of checklists that may be used to design a CoP.

Chapter VI summarizes the research and analysis, recommends areas for further research, and concludes with recommendations for Tenth Fleet to move forward with the proposed CoP for programmers and developers.

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II. COMMUNITIES OF PRACTICE

Theorists Jean Lave and Etienne Wenger coined “Communities of Practice” [5]. Though the CoP term is relatively new, the concept has been practiced for several decades in groups that have found that knowledge sharing and collaboration can provide valuable benefits for organizations. In this chapter, Section A defines a CoP. Section B explains why CoPs are important. Section C culminates with a case for creating a Navy CoP for programmers and developers.

A. WHAT IS A COMMUNITY OF PRACTICE

Communities of Practice are groups of people who share a common interest in a subject and collaborate over time in order to create solutions or develop innovations. There are various definitions of Communities of Practice. Communities of Practice are “groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly” [6]. They “often focus on sharing best practices and creating new knowledge to advance a domain of professional practice” [7]. Additionally, CoPs are “groups that form to share what they know and to learn from one another regarding some aspects of their work” [8]. Knowledge transfer is so central to the idea of CoPs that, “learning can be the reason the community comes together or an incidental outcome of member’s interactions” [6]. Therefore, though CoPs may take different forms, a central focus on the broad diffusion of expertise is essential to the concept.

According to Wenger, “three characteristics are crucial to defining a CoP: the domain, the community, and the practice” [6]. A domain has an identity, typically a shared area of interest. Members of a CoP are committed to the domain, and have a shared skill set that distinguishes them from the general populace. The community is created by members who “engage in joint activities and discussions, help each other, and share information” [6]. Members within the community “develop relationships that enable them to share and learn from one another” [6]. Again, CoPs may take different

forms, but there are defining characteristics of CoPs that are common across different domains.

Fred Nickols [9], an independent management consultant who has authored numerous CoP guidebooks, builds on Wenger's list with three additional characteristics – *joint enterprise* through negotiated meaning, *mutual engagement,* and *shared repertoire.* Nickols describes a *joint enterprise* as one where members of a CoP accomplish a task on a continuous basis with some kind of commonality between individuals and a clear understanding of the larger purpose of the work. In short, they have a unified vision. He believes mutual engagement occurs when "the members of a CoP interact with one another not just in the course of their work assignments but to clarify that work, to define how it is done, and even to change how it is done" [10]. According to Nickols, shared repertoire means that, "the members of a CoP have not just work in common but also methods, tools, techniques and even languages, stories and behavior patterns" [9]. All three characteristics and qualities overlap and are inseparable. Collectively, they work together in order to determine the practice. Conversely, the practice also refines the way each of these characteristics is reflected in the unique community.

The term *practice,* in a CoP, refers to a skill set shared among CoP members. As defined by Wenger, "members of a community of practice are practitioners. They develop a shared repertoire of resources: experience, stories, tools, ways of addressing recurring problems—in short a shared practice" [7]. This shared *practice* takes time to mature and continues to develop through sustained interaction. As defined in the Merriam-Webster dictionary, the term *practice* refers to something that is completed on a regular basis [11]. Practice is commonly understood as it refers to the professional activity of doctors, dentists or lawyers and their *practices*.

Practice is not a term generally used when referring to software programmers or developers; however, the skills associated with programming and software development are constantly being improved upon. They are developed from a shared repertoire and completed on a regular basis. Thus, we assert that programming and developing software is a practice, and we will refer to individuals who engage in this practice as programmers and developers.

Communities of Practice may self-organize or be sponsored [12]. This thesis focuses on sponsored CoPs because of several structural advantages of the sponsored model for communities. Specifically, sponsored CoPs are typically "initiated, chartered, and supported by management" which often results in monetary support and resources for the community [12]. Additionally, sponsored CoPs:

1. Enable colleagues to learn from one another through the sharing of issues, ideas, lessons learned, problems and their solutions, research findings and other relevant aspects of their mutual interest.
2. More broadly share and better leverage the learning that occurs in the CoP with others.
3. Generate tangible, measurable, value-added benefits to the business. [12]

Given that this thesis is targeted for the planned design of a Navy CoP for programmers and developers we naturally focus on the sponsored model for a community.

In summary, a CoP is a collaborative team that communicates and seeks to expand knowledge in a particular practice. A CoP is defined by its identity through a domain, its members through the community, and the skill set of practitioners in the *practice*. Sharing of knowledge and resources eventually evolves into a shared repertoire for the *practice* of specific CoP-related skills [7]. As practitioners, over time and through mutual engagement, members of the CoP eventually develop a shared repertoire of resources. This shared repertoire may be used to improve an organization's mission. These resources could include tools, experiences, stories, and lessons-learned. These types of interactions occur over an unspecified amount of time and through consistent interactions. Finally, the CoP envisioned in this research reaps the benefits of strong sponsorship.

B. WHY ARE COMMUNITIES OF PRACTICE IMPORTANT?

Communities of practice are important because they expand social networks through mechanisms that will be examined in future sections of this thesis; however, the central assertion of this work is that expanded social networks "help people organize around purposeful actions that deliver tangible results" [13]. CoPs are "where best

practices and innovation fires emerge and where the solutions to shared problems are first identified" [12]. It is the increased productivity, creativity, and adaptability of the community to the sponsor's challenges that holds the potential for a Navy CoP proposed in the next section. Before making that specific case, we look more closely at the value proposition in a CoP's ability to build global networks, stimulate learning, and deliver quantifiable results.

CoPs connect individuals globally across different societies, demographics, and levels of expertise. For example, a collaboration tool that enables CoPs to connect individuals globally, and provides a venue to network, share information, and enable dialogue is GitHub. GitHub is an online code repository hosting service that claims to host "36 million visitors each day" [14]. According to one study [15], "the software development community has embraced GitHub as an essential platform for managing their software projects." This same study also revealed that GitHub "provides a traceable project repository, but also provides a social meeting place for all interested parties supporting CoPs. GitHub is emerging as a collaborative platform for education with features for managing and improving—perhaps even transforming—the learning experience". GitHub supports "open collaboration within commercial organizations by centralizing tools and information and making them transparent" [16]. This is further "advocated by developers acting as change agents, the organic adoption of the tool and its corresponding process that can ensure commonality between toolkits to utilize" [16]. This collaboration tool has enabled successful CoPs to connect individuals, organize around a certain domain identity, and provide structures that promote regular, active interaction and the sharing of knowledge.

CoPs are also important because they stimulate learning, capture and diffuse existing knowledge, and provide a platform for mentoring and coaching. This structure encourages members to improve within their practice, because the CoP introduces "collaborative processes to organizations, and encourage the free flow of ideas and exchange of information" [13]. Organizations that adopt a CoP and reap these benefits inherently provide their workforce opportunities to further excel in their practice.

An online CoP that values learning, mentoring, and coaching is Stack Overflow. Stack Overflow is an online question and answer website with a community of approximately 4.7 million programmers [17]. Stack Overflow supports these values through three common properties of social learning technologies to include: "support to learners in locating the correct content, allows learners to connect with the right people (question tags show what domain of expertise is needed and people with that expertise can answer the question), and motivate/incentivize people to learn" [18]. Stack Overflow provides an online platform "for developers to post their programming questions and for fellow developers to provide answers" [19]. The website allows anyone interested in programming to join, ask questions, and receive timely feedback. As the questioner, they "can add a few tags to questions to help others (e.g. potential responders) better understand the question as well as select one answer as the most helpful one, and then site members can vote on questions and answers" [19]. The quality of questions and answers is determined by its dedicated community of users who vote on and improve posts through constructive feedback and have the ability to reject questions not pertaining to the identified focus [19]. Furthermore, Stack Overflow places significant importance on its members and encourage them through reputation points to take ownership of the website and community at large. Through active member participation, the free flow of ideas, constructive feedback, and collaboration, Stack Overflow members improve the practices of each other through shared learning, mentoring, and coaching.

Communities of practice are also important because the community collaborates to produce useful products [13]. A successful CoP that exemplifies this value is TopCoder, a company that administers and hosts technical competitions in computer programming. With 1,020,945 active members (as of May 3, 2016), it is one of the largest online technical communities in the world [20]. TopCoder focuses on competition *and* community. TopCoder is a crowdsourcing platform used by enterprises to "deliver their software developing tasks" to be competed for by TopCoder members [21]. Though TopCoder is competitive in spirit, one study observed that their competitions are "never disrespectful or nasty, instead people like to help each other" [22]. TopCoder forums are "the main source for collaboration, where less experience community members ask for

assistance on certain problems and receive instant feedback from more experienced competitors" [22]. These forums provide members "opportunities to network professionally and socially" [22]. Aside from collaboration, the competition mechanism has "ensured high-quality solutions" for each phase of competition [21]. Sponsors of TopCoder shape competitions in order to compete and deliver "cost effective and time efficient" products [22]. This exemplifies how a community can collaborate together to produce tangible results.

In summary, CoPs are important because of the tangible results they yield, but these measurable outcomes are the product of less quantifiable values. One of the most important intangible values of a CoP is the expanded social network, which fosters learning through knowledge sharing and provides mentorship and coaching opportunities. Additionally, CoPs "capture and diffuse existing knowledge, while introducing collaborative processes to help people organize and generate new ideas" [13]. Therefore, the Navy may benefit from a CoP for programmers and developers.

C. A CASE FOR A NAVY COMMUNITY OF PRACTICE FOR PROGRAMMERS AND DEVELOPERS

The Navy's formal and informal cyber workforces stand to benefit from a CoP sponsored by the formal cyber workforce. A CoP would provide tangible benefits for the formal cyber workforce to include increased effectiveness and mentorship in the execution of cyber operations. Tangible benefits to the informal cyber workforce include expanded professional networking and coaching that could result in increased cybersecurity for the creation, sustainment, and operation of computer-dependent systems outside of those dedicated to the execution of formal cyber operations. A Navy CoP for programmers and developers could provide these benefits while simultaneously providing an operational mechanism to deliver outcomes articulated by the Chief of Naval Operations and the Secretary of Defense.

In order to articulate the benefits of a Navy CoP to the formal cyber workforce it is important to first understand a little more about the structure of the officers engaged in cyber tool development. Cyber Warfare Engineers (CWEs) comprise the active duty

naval officer component of cyber tool development within the Cryptologic Warfare Community [23]. A structural challenge identified in anecdotal conversations within this small cadre tasked with programming in support of Fleet Cyber Command operations and missions is the lack of coaching and mentorship provided by experienced software developers to the junior officer CWEs. After their five-year obligation of service CWEs matriculate out of the program and must transfer into different communities within the Navy or resign their commission and move on to a civilian career, leaving the next generation of CWEs without experienced mentors. This matriculation and transferring of CWEs does not all happen at once, they are continuously rotating in and out of the ranks and workforce. The formal cyber workforce stands to take advantage of this global network of former CWEs to address the lack of mentoring and coaching they currently experience. The structure and design of a CoP would allow for both current and past CWEs to socially network, share knowledge, and coach one another. A CoP would offer global accessibility to all CWEs, reducing loss of knowledge and experience and could alleviate some of the lack of coaching and mentorship challenges experienced among CWEs due to their community structure and matriculation rate.

Another structural challenge identified in anecdotal conversations within the Cryptologic Warfare community reveal that some Cryptologic Warfare officers are inclined to focus on cyberspace operations, but must rotate between other areas in order to compete for promotion. For example, after many officers complete a tour executing cyberspace operations they are then encouraged to diversify their career with a tour in another field such as signals intelligence. This creates officers who are generalists across a broad field of naval capabilities but diffuses the expertise of officers who are more inclined to focus on the practice of programming and developing as related to cyberspace operations. Creation of a Navy CoP for programmers and developers would allow experienced Cryptologic Warfare officers with an interest in cyberspace operations a way to stay connected and close to the community while they serve in billets aligned to signals intelligence or other responsibilities.

Next, a Navy CoP could bridge the gap between the formal and informal cyber workforces caused by different levels of experience and classification barriers. Bridging

this gap could provide the tangible benefit of increased cybersecurity for Navy capabilities outside of the Tenth Fleet mandate. The large informal cyber workforce that includes requirements definition at the Office of the Chief of Naval Operations level, program oversight from the many Program Executive Offices, and systems command programmers and developers is challenged with the responsibility of generating platforms that are exposed to adversary cyberspace operations, but the system developers often lack knowledge of enemy capabilities. In addition to this shortfall in knowledge, the classification levels of systems, tools, and capabilities often discourages cross-collaboration among the formal and informal cyber workforce resulting in systems designed without full visibility of the operating environment in which they will be expected to fight and win. By comparison, the formal cyber workforce is much smaller than the large community of Navy programmers and developers in the informal system [24]. However, the small formal workforce is much more familiar with adversary cyber warfare capabilities and its members are cleared and granted access to the required classified information needed to conduct their mission unlike their counterparts. A CoP would unite the formal and informal workforces through collaboration, and enable dialogue resulting in a repertoire of shared knowledge, best practices, and techniques. The desired output from this increased collaboration and knowledge diffusion could be increased cybersecurity of computer dependent systems designed and fielded by the informal workforce.

Additionally, we assume that a CoP would address needs of both the formal and informal cyber workforces while simultaneously supporting the Chief of Naval Operations (CNO) desired goal of high velocity learning. The CNO defines high velocity learning as “a Naval force that produces leaders and teams who learn and adapt to achieve maximum possible performance, and who achieve and maintain high standards to be ready for decisive operations and combat” [25]. This definition, taken from the CNO’s *A Design for Maintaining Maritime Superiority,* reflects his highest priority guidance to the Navy. An expansion of the Navy’s formal and informal workforces to include collaboration with industry could enhance high velocity learning because of the shared knowledge and experience among workforces.

As highlighted in the Secretary of Defense's (SECDEF's) recent DOD cyber strategy document, "to succeed in its mission the DOD must operate in partnership with other Departments and Agencies, international allies and partners, state and local governments, and, most importantly, the private sector" [26]. (Note: we use the term industry to identify the private sector of programmers and developers referred to in the SECDEF memo.) We believe a Navy CoP that includes industry participation would operationalize the partnership that SECDEF is encouraging, and expose the Navy to industry's best practices in software development and programming. Without a mechanism to bring about the aforementioned partnerships the formal and informal workforces may not be aware of the latest cybersecurity technologies. Exposure to industry would allow both workforces to better understand cutting edge tactics, techniques, tools, and procedures that could be used to improve and quicken the Navy's iteration cycle of tool and capability development.

Another important reason for including industry in a proposed Navy CoP is to bridge the gap between commercial cybersecurity and military cyber warfare. As a military force the Navy conducts cyberspace operations under a different set of permissions and laws than the commercial sector. U.S. Code Title 10 and Title 50 authorities govern Navy conduct for cyber warfare, which is fundamentally different than commercial cybersecurity laws enacted in the Cyber Security Act of 2015, Cyber Security Enhancement Act, Electronic Communications Privacy Act, Digital Millennium Copyright Act, or the Computer Fraud and Abuse Act [27].

As previously mentioned, military and industry must abide by different laws and restrictions when conducing cyberspace operations. A CoP would provide a forum for industry to learn about the nuances of Navy requirements that are different from their other customers. Potential challenges stemming from acquisition or export control policies and regulations for example, could be addressed as the community evolves. If industry were an active participant in the CoP then knowledge transfer to and from the Navy would occur. Industry would benefit from a more comprehensive understanding of a cyber warfare paradigm the Navy operates under, allowing industry to further innovate

and improve their tools and capabilities to assist in improving Navy processes and capabilities.

In summary, this thesis assumes that a CoP provides bi-directional tangible benefits to the formal and informal cyber workforces as well as industry. The formal cyber workforce benefits from the global access to former CWEs who would provide the needed support and mentorship to future CWEs. The formal cyber workforce also stands to benefit from increased productivity among its Cryptologic Warfare officers who are inclined to focus on cyberspace operations even while assigned to billets in other mission areas. The informal cyber workforce would benefit from knowledge required to increase cybersecurity of computer-dependent systems outside of Fleet Cyber Command's span of control. Industry would benefit from exposure to the Navy's cybersecurity needs and requirements, and the Navy would benefit from exposure to industry's best practices, tools, and techniques. All of these benefits are due to the structural way that CoPs bring individuals together. Expanded social networks allow individuals to apply knowledge in ways that may result in "new solutions to old and new problems" [9]. Therefore, due to the potential tangible benefits to be gained, it is in the best interest of the Navy to design and sponsor a Navy CoP for programmer and developers with the characteristics identified in the following chapter.

III. KEY CHARACTERISTICS OF SUCCESSFUL COMMUNITIES OF PRACTICE

All CoPs are unique; however, successful CoPs often have common traits. Chapter III will focus on three shared key characteristics of successful CoPs to include: social interactions, structure, and lifecycle. This chapter also examines existing communities that have been successful by exhibiting the aforementioned characteristics. These existing communities and characteristics should be used as a point of consideration when designing a Navy CoP for programmers and developers.

A. SOCIAL INTERACTIONS

Successful CoPs promote social interactions through collaboration, discussion, and knowledge sharing. These interactions may occur in various environments to include: "face-to-face, video/audio teleconference, telephone, electronic mail, and website access devices" [28]. Furthermore, these interactions should generate energy that encourages active engagement and participation. There has been limited recent research conducted on the value of periodic face-to-face meetings compared against virtual communities. Despite this shortfall in literature, this thesis will explore two common forms of social interactions, face-to-face and virtual technology, as seen in successful communities, and how these environments contribute to the success of communities.

Face-to-face interactions involve two-way dialogue where immediate feedback can be received, allowing individuals to better express and gauge how ideas are being perceived. A 2013 study by the *Harvard Business Review* revealed, "87% of professionals believe face-to-face meetings are essential for completing a business transaction, and 95% said they are key to successful, long-lasting business relationships" [29]. Face-to-face interactions are intended to bring individuals together with the intent to share and express ideas and information. Face-to-face interactions allow a diverse group of individuals to interact in an environment where their message is heard with a decreased chance of miscommunication or interpretation.

The Athena Project is a community that thrives on frequent face-to-face social interactions in various geographical areas. The Athena Project was an "initiative founded in the Navy Surface Community aboard USS *BENEFOLD (DDG 65)* in early 2013" [30]. The Athena Project focuses on "harnessing deckplate innovations to create a cadre of forward-thinking, creatively confident Sailors of the Fleet of tomorrow" [30]. Utilizing an open forum platform, Sailors can "pitch innovative ideas to improve their command or the Navy" [30]. The Athena Project aims to host quarterly events for San Diego and Norfolk naval bases as well as the Pacific Northwest. These events provide Sailors a venue to share and develop their ideas to improve their unit or service, and ultimately affect change. The successes of Athena Project events are attributed to face-to-face social interactions that bring together individuals from all communities within the Navy, and provide them a venue to share ideas and concerns in order to improve processes and policies within the Navy. Success stories shared on the Athena Project website include projects that have been "published as tactics, techniques, and procedures that have also been adopted throughout the fleet" [30]. As demonstrated by the Athena Project, face-to-face interactions may occur in small exclusive settings, or large international events discussed next.

Cybersecurity conferences provide energy and engagement that take advantage of the benefits gained from social interactions. Two well-known annual cybersecurity conferences that showcase hacker practices to a range of participants are DefCon and Black Hat. DefCon is hosted annually in Las Vegas, and is one of the oldest open cybersecurity conferences in existence [31]. DefCon "attracts top level cybersecurity researchers and hackers interested in software, computer architecture, hardware modification, and code-scripting" [31]. Black Hat was developed from DefCon 20 years ago and attracts 8,000 attendees each year [32]. Cybersecurity conferences such as these provide an opportunity for professionals to learn about developing technology, receive valuable insights from cyber leading experts, and network with other professionals in the cyber workforce. Face-to-face interactions allow a diverse group of individuals from all walks of life to interact and share information with the expectation of immediate feedback.

Given consistent advancements in technology and newer generations learning how to operate computers early in life, virtual interactions often appeal more to the "millennial" generation [33]. A research study [34] on virtual teams conducted in 2015 examined the past ten years of literature and studies on virtual teams. One benefit of virtual teams was outreach to the millennial generation. The study stated that the millennial generation's exposure to virtual methods at a young age has increased their comfort and acceptance of virtual technology as a means to socially interact. Additionally, the millennial generation "has the ability to effectively utilize broadly networked digital communication technologies to quickly and seamlessly accomplish a wide variety of tasks" [35]. Furthermore, working together virtually aligns with the "values and expectancies of younger employees" who "place a greater value on work-life balance" [34]. In order for a community to be successful through the use of virtual interactions, "members of an organization need to be comfortable with participating in a computer-mediated, internet-based community of practice, which involves very little face-to-face communication" [36]. The key to virtual interactions is a virtual platform that is simple to learn and operate for all individuals.

Web-based platforms are ideal for virtual interactions because of their ease of operations and ability to connect a global audience. All Partners Access Network (APAN) is a "U.S. DOD social networking website that has been used for over a decade primarily for information sharing and global collaboration" [37]. APAN's website [37] hosts a network of communities that allow users to post multimedia, blogs, wikis, forums, documents, and a variety of information to a communities' specific page. Their website provides organizations and individuals with unclassified tools to communicate worldwide. Collaboration tools offered on APAN's webpage can be utilized standalone or combined in order to design and develop a specific community space. Furthermore, APAN's website provides a virtual place for individuals worldwide to connect and collaborate. Virtual interactions are beneficial to CoPs because of their low cost to operate, decrease in travel time, and ability to rapidly make decisions around the globe [38]. More often than not, the audience of a CoP will determine the type of social interaction that is most appropriate and more likely to contribute to the CoP's success.

In conclusion, social interactions support the importance of CoPs by connecting practitioners, encouraging collaboration, and enabling knowledge sharing. Social interactions can be conducted face-to-face or virtually. The type of social interaction selected by a CoP is often determined by the intended audience, and takes into consideration their experience and needs. Both forms of social interactions have advantages and provide benefits to a CoP, and both will be necessary to sustain the proposed Navy CoP for programmers and developers because of the diverse experience, demographics, and the geographic mobility of its members.

B. STRUCTURE

Successful CoPs operate in various ways, but they share four common structural elements: 1) sponsors, champions, and stakeholders, 2) mission, vision, and purpose, 3) a membership framework, and 4) measures of success. This section explores these structures and includes examples of each in successful communities.

1. Sponsors, Champions, and Stakeholders

Successful CoPs rely on sponsors, champions, and stakeholders to promote, grow, and sustain their community. It is important to have a committed sponsor "who is able to envision the benefits of a community of practice over time, and has a sense of how the community can interact across sectors" [39]. Furthermore, committed sponsors are "invaluable to the resourcing and sustainability of a community" [39].

Sponsors are "the bridge between a CoP and the rest of the formal organization, particularly the authority hierarchy" [40]. The sponsors' responsibilities include: "articulate CoP mission, manage official relationships, remove barriers and obstacles preventing CoP productivity, run interference as necessary, and provide funding as needed" [40]. A CoP may have one or more sponsors.

A CoP champion is "the chief organizer of events" [40]. The champion's responsibilities include: "ensure and articulate valid CoP purpose(s), generate CoP interest, organize face-to-face events, stimulate energy and enthusiasm, promote participation and contributions of CoP, obtain official support as needed, communicate

contributions of CoP to formal organization or seniors, and communicate company support to CoP members" [40]. The champion is the glue that brings together the members of a CoP.

Stakeholders of a CoP are people or organizations internal or external to the CoP that have an interest in the CoP's mission, as well as influence over the efforts and outcomes of the CoP [41]. The stakeholder's responsibilities may include: "reviewing, approving, and funding of deliverable project items" [42]. Stakeholders may strengthen the organization's relationships with other stakeholders, because of common shared interests in CoP mission accomplishment. Stakeholders provide a CoP with credibility and legitimacy, often due to the stakeholder's rank, status, or reputation. However, stakeholders can also act as a barrier to the evolution of a CoP [41].

Stakeholders often have the most influence over the success of CoP because of their vested interest in the CoP's outcomes and products. The Joint Interagency Field Experimentation (JIFX) program is an excellent example of how important stakeholders are to the success of a community. JIFX is a Naval Postgraduate School (NPS) program that hosts quarterly events at Camp Roberts, California Army National Guard Training camp in order to "provide a field experimentation resource for its stakeholders—the Unified Combatant Commands and other federal agencies to inform the requirements generated by these entities" [43]. JIFX is "sponsored by the Office of the Secretary of Defense and the Department of Homeland Security" [43]. JIFX's primary stakeholders are the higher echelon commands, and secondary stakeholders include all other DOD organizations, interagency and federal organizations, and state and local government organizations [43]. The stakeholders define, delineate, and eliminate requirements for JIFX events. JIFX's decade of successes may be attributed to their meaningful stakeholders, as well as their sponsors that motivate individuals to join the community, solve issues, and produce tangible results for current military projects and missions. The legitimacy and credibility gained from stakeholders' reputations within the government may positively influence participation and outcomes of the CoP.

In conclusion, sponsors, champions, and stakeholders provide invaluable resources and support to a CoP. Their legitimacy and credibility often garner active

participation and influence events that produce tangible products. They promote the CoP and fund events. Their support and active involvement is important to the sustainment of a CoP.

2. Mission, Vision, and Purpose

Structural elements common to successful CoPs are clear and concise mission and vision statements and a well-defined purpose. Mission statements should clarify the organization's measurable goals and objectives. The vision statement further explains the CoP's values. These statements should be short and concise, but provide enough information that a potential member can clearly envision how they may benefit or contribute as a future CoP member. If appropriate, mission and vision statements should be aligned with those of the CoP's sponsoring organizations [13]. These statements should be easy to access in order for all interested individuals to understand a CoP's purpose.

Successful communities make their mission and vision statements accessible for the public to view. The Military Cyber Professionals Association (MCPA) provides clear, concise, and well-defined mission, values, and goals statements on their website [44]. In 2013, Army Major Joseph Billingsley, while an NPS student, identified a "need for a cyber association in order to merge the myriad of professionals in the cyber operations field" [45]. According to the MCPA website [44], MCPA's mission is "dedicated to developing the American military cyber profession and investing in our nation's future through Science, Technology, Engineering, and Math education" [44]. Their vision is to establish "an American military cyber profession that is accomplishing what our nation needs, expects, and deserves" [44]. MCPA only recruits members who believe in their mission, vision, and support improving cyber interests, thereby putting extra emphasis on the importance of clear and concise mission and vision statements accessible to all interested individuals. Public access to CoP mission and vision statements inform interested participants what the goals of a CoP's and goals purpose.

Successful CoPs have well-defined purposes that highlight the value of active participation in the CoP. Two common purposes found in successful CoPs are learning

through shared knowledge and collaboration, and the act of taking purposeful action in order to successfully execute tasks and projects. A CoP evolves when members learn from each other and develop a shared practice. A "balance between the production of tools and deep learning experiences for CoP members" is key to successful practice development [13]. Purpose statements often focus on benefits gained as members of a community. CoP purposes are typically member-focused in contrast to mission and vision statements, which are sponsor outcome focused.

In conclusion, successful CoPs use mission, vision, and purpose statements to harmonize their internal and external messaging about the community. Mission statements outline the CoP's objectives, and goals. Vision statements further outline the CoP's values. The purpose(s) of a CoP highlight to members the benefits gained from shared knowledge, collaboration, and actions taken that result in tangible results. Mission, vision, and purpose should be displayed for the public to see in order to seek and inspire individuals to become an active member of the CoP.

3. Membership Framework

A third structural element of successful CoPs is clear membership frameworks. The desirable characteristics of a membership framework that we want to emulate are inclusive membership and commitment. Inclusive membership benefits include the expansion of social boundaries such that cross-collaboration results in a diverse spectrum of solutions to a problem. Committed member benefits include a sense of identity shared among CoP members, which contributes to their commitment to each other and the success, and longevity of the CoP.

Inclusive membership enables recruitment from a more diverse group of individuals with different mindsets and opinions, which can bolster the productivity and diversity in ideas gained through CoP events. Massive Mutiplayer Online Wargame Leveraging the Internet (MMOWGLI) is a platform used by the Navy to crowdsource ideas and solutions to some of the Navy's current problems [46]. MMOWGLI has previously been "used by the Office of Naval Research and other U.S. government agencies to perform online "wargames" to study various problems and hypothetical

scenarios" [47]. MMOWGLI harnesses the potential of large, diverse groups for thinking and responding to emergent challenges and opportunities [48]. MMOWGLI provides a forum for individuals to share knowledge and socially interact, which could add value to rapidly developing ideas for how to achieve a CoP's desired outcomes and impacts. MMOWGLI's inclusive membership invites all interested individuals, regardless of association or geographic location, to participate in wargames and share their ideas for how to combat Navy problems. Inclusive membership is ideal for a successful Navy CoP for programmers and developers, because of the potential increased number of participants and innovative thinking that may emerge from encouraging dialogue across a worldwide spectrum of individuals.

The commitment of CoP members can be affected by the shared identify of its members, often resulting in longer lasting membership commitment. The commitment of CoP members directly affects the longevity of a CoP. The United States Navy's Chief's Mess, while an exclusive CoP, is a well-established CoP within the Navy with a long-standing history, tradition, and firm commitment to and from each member. They extend its membership to all active and retired indoctrinated Chief Petty Officers. The title of "Chief" is a very distinctive and personal form of identity. This unique identity further extends the understanding of deep trusting relationships among members of The Chiefs Mess. The Chiefs within this organization maintain a lifetime commitment to each other. They build their identity through shared information, trust, activities, a commitment to personal and professional growth of the Sailors they are entrusted with leading, and the successful completion of the Navy's many missions. This identity also adds to the sense of cohesion that is found within The Chief's Mess. This fostered sense of identity forms one of the largest CoPs in any of the military branches. The focus of identity adds a human dimension to the idea of practice and identifies the level of commitment to others who share that same practice. CoPs require significant and sustained levels of participation from theirs members in order to persist.

In conclusion, the envisioned Navy CoP for programmers and developers should reflect the inclusiveness of participants as exhibited MMOWGLI, and the commitment of its members as exhibited in the Chief's Mess. While MMOWGLI and the Chief's Mess

exhibit the right characteristics to emulate when creating the proposed Navy CoP for programmers and developers, there is potential for unforeseen challenges to a design that includes inclusive membership that fosters membership commitment. These challenges may be overcome in proper design and attention given to the types of interactions that encourage inclusiveness and commitment.

4. Measures of Success

A fourth structural element common to successful CoPs is the establishment of metrics to quantify success. Success is subjective and may be determined by anything including the number of active members, events, successful outcomes, or the CoP's lifespan. CoP sponsors, champions, stakeholders, and members all provide multiple perspectives on what constitutes success. Therefore it is important to clearly communicate how success is envisioned. Continuous evaluations of success should be conducted in order to analyze and measure the rate of success and adjustments made for CoP improvement and sustainment.

Established metrics used to evaluate a CoP's success are imperative to the sustainment and further support of a CoP in order to manage expectations and make adjustments as necessary. CompanyCommand, an online community that has been connecting Army company commanders for over 13 years, exemplifies the importance and benefits of established and defined metrics for how to measure success [49]. CompanyCommand's initial success was evaluated by the use of metrics to include "quantitative measures of unique/repeat visitors, number of downloads, subjects searched for and found, submission rates, and time saved in wheel re-invention" [50]. In 2002, the CompanyCommand.com site served "352,000 unique visitors who downloaded 136 gigabytes of information, logged 16 million hits, and viewed 2.7 million pages" [50]. These quantitative measures made by CC champions and stakeholders eventually garnered further support from additional sponsors. In 2003, as operations in Iraq gained momentum and frequency, more Army Officers began utilizing the website to assist them while deployed. The Army eventually recognized the value of this community and "pledged to support the further development and growth of their CoP as well as other

supporting CoPs at other levels of leadership (i.e. PlatoonLeader.net)" [50]. Established and pre-determined metrics and methods to measure rate of success may generate further CoP support and sponsorship.

How one CoP measures success may not be what works best for another CoP, but many successful CoPs have used metrics to generate and sustain sponsorship. Sponsors may provide valuable inputs for how to measure success or envision what it looks like. The continuous evaluation of metrics used to measure success of a CoP is necessary in order to adjust for changes as needed. Two of the characteristics shared by successful CoPs, social interactions and structures, all contribute to the third shared characteristic, lifecycle.

C. LIFECYCLE

The lifecycle of a CoP follows natural self-governed iterations controlled by the community. CoPs have lifespans—they emerge, grow, and either end or sustain. One sign of a successful CoP lifespan is if "over time the energy, commitment and visibility provided by its members grows until it becomes institutionalized as a core value-added capability of the sponsoring organization" [13]. The model seen in Figure 1 depicts a composite of several organizations and outlines the lifecycle phases of communities.

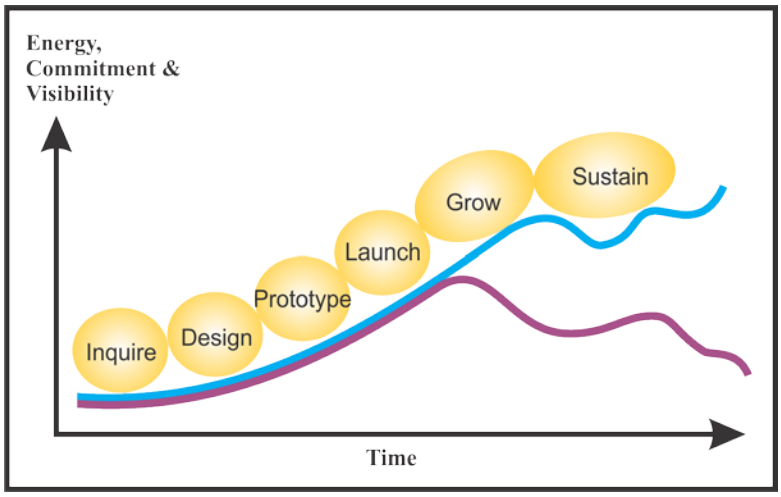

Figure 1. Community of Practice Lifecycle Phases. Adapted from [13].

We can see in Figure 1 that there are six phases within the lifecycle of a CoP. These phases include: “Inspire, Design, Prototype, Launch, Grow, and Sustain” [13]. The first phase, inspire, focuses on the “process of exploration and inquiry, identifies the audience, purpose, goals, and vision for the CoP” [13]. The second phase, design, is where we “define the activities, technologies, group processes, and roles that will support the CoP’s goals” [13]. The third phase, prototype, is where we “pilot the community with a select group of key stakeholders to gain commitment, test assumptions, refine the strategy, and establish a success story” [13]. The fourth step, launch, is where the CoP is introduced to a “broader audience over a period of time in ways that engage newcomers and deliver immediate benefits” [13]. The fifth step, grow, is where we “engage members in collaborative learning and knowledge sharing activities, group projects, and networking events that meet individual, group, and organizational goals while creating an increasing cycle of participation and contribution” [13]. Last, the sixth step, sustain, focuses on how to “cultivate and assess the knowledge and products created by the CoP in order to inform new strategies, goals, activities, roles, and technologies for the future” [13]. Additionally, the blue line represents the positive results of a CoP over time if the right amount of energy, commitment, and visibility is given to all phases, whereas, the red line shows the gradual dissolution of the CoP as a result of neglect. The lifecycle phases of a CoP are cyclic and may change depending on learning and reflection. While not displayed in Figure 1, the lifecycle phases of communities are a continuous repeating cycle of trials and approaches, and each step may be revisited at any time to implement and try different methods.

The iterative nature of CoP development suggests that it takes time for CoPs “to emerge, to flourish, and to become productive” [12]. Leadership or sponsors cannot mandate the lifecycle of a CoP, nor can a CoP be “managed in a heavy-handed way” [12]. If the CoP is managed incorrectly, it will more than likely discourage active participation and shorten the CoP’s lifecycle. CoPs, as previously discussed in reference to the Chief’s Mess, are “an investment in the organization’s future, not a quick fix to be applied for the sake of short-term gain” [12]. Thus, the mission, vision, and purpose are commensurable with the lifecycle of a CoP and will evolve with the community.

However, opportunities exist for CoP sponsors to use knowledge of a CoP's lifecycle to guide the positive development of an active community.

One specific way sponsors, champions, and stakeholders may move a CoP toward growth and sustainment is by designing and clearly communicating member benefits. CoPs often grow "based on the increasing benefits individuals or organizations accrue from participating in the activity" [28]. Benefits therefore may be directly linked to the lifecycle of a CoP. Defined benefits provide potential participants of a CoP with reasons to become an active participating CoP member. Benefits accrue from participating in an activity, and may include rewards or recognition, which can contribute to personal satisfaction. Benefits gained by participants can be evaluated and examined through multiple iterations and prototypes of CoP sponsored events. Furthermore, successful CoPs solve important problems that may have a positive impact on the CoP and "retain a substantial percentage of its members, but also attract new ones" [28]. Therefore, investment in defining the benefits gained by sponsors, champions, stakeholders, and members of a CoP may positively influence the lifecycle of a sponsored CoP.

In summary, it is helpful to understand a CoP's lifecycle phases in order to establish and maintain a successful community. Members of the community have the largest role in determining the ultimate success or failure of their community, but sponsors can help define membership benefits, which directly affect CoP longevity. Regular assessments should be made of the CoP in order to determine the current lifecycle phase of the CoP and if necessary make changes to the CoP structure that influence it along the path of growth and sustainment.

D. CONCLUSION

Successful CoPs are defined by common characteristics to include: social interactions, structure, and lifecycle. Members of successful CoPs often interact in regular and frequent social interactions either face-to-face or virtually as a means to share knowledge and collaborate. The structure of a successful CoP consists of sponsorship support, clear and visible statements that define the CoP's goals and objectives, inclusive membership and shared identities in a members' practice that may increase long-term

CoP commitment, and metrics to evaluate and measure success. When creating a CoP for Navy programmers and developers, momentum and vision might be lost at any particular phase, which could result in the designed “CoP not achieving the overall support needed to evolve into a sustainable entity” [13]. Therefore, the remainder of this thesis examines techniques to design a community with these key characteristics in order to promote its successful establishment.

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IV. DESIGNING A COMMUNITY OF PRACTICE: APPROACHES AND TECHNIQUES

Chapter II made a case for why the Navy needs a CoP for programmers and developers. Chapter III highlighted the key characteristics of successful CoPs. Chapter IV focuses on how to create and design a CoP and explores the relationship between design, Design Thinking, and human-centered design. Finally, Chapter IV selects a design approach that will be used for making recommendations on how to design the proposed Navy community of practice.

A. WHAT IS DESIGN?

Design approaches focus on end-results from the viewpoint of users and it can be quite effective in the developmental stages of a CoP. Design is a process that has "evolved rapidly since World War II" [51]. The word *design* takes on "a variety of noun and verb meanings" in the English language, and "has meanings ranging from the abstract conception of something to the actual plans and processes required to achieve it" [52]. According to Nigel Cross, British academic, design researcher, and educator, "Everyone can—and does—design. We all design when we plan for something new to happen. To design things is normal for human beings, and 'design' has not always been regarded as something needing special abilities" [53]. As defined by Richard Buchanan, world leading design theorist, design is "the effort of people to make the products that serve us in our everyday lives" [54]. Though the term *design* is not a new concept or method, it has evolved over the centuries in its use and definition.

Historically great works were designed by single minds such as Homer, Shakespeare, and Leonardo da Vinci, but design processes increasingly focus on the viewpoint of users through the collaboration of many minds. According to Frederick Brooks, a designer for the past six decades, the two biggest changes in design since the 1990s are that it is accomplished "mostly by teams, rather than individuals, and design teams now often collaborate by using telecommunications, rather than by being collocated" [51]. Design can refer to the shared dialogue between individuals, resulting in

the basis for thought processes and collaborative efforts. It can be viewed as a "way of knowing through thinking and doing, as well as from giving form to ideas to a way of doing things" [55]. Design is focused on the collaboration of people working together in efforts to create tangible products. One potential barrier of incorporating the concept of design within an organization is the misunderstandings associated with what design is and is not.

While the value of design approaches is well documented in Robert Curedale's book, *Design Thinking Processes & Methods Guide,* organizations often dismiss the use of design due to a lack of knowledge about "what design is or why it matters" [49]. John Heskett, design scholar, attempts to diffuse this misunderstanding in his definition of design, "Design, stripped to its essence, can be defined as the human nature to shape and make our environment in ways without precedent in nature, to serve our needs, and give meaning to our lives" [56]. Organizations can benefit from the practice of design and its ability to "tap into group intelligence, creativity, and ambition to make a meaningful impact in the user's life, both functionally and emotionally" [55]. Dispelling misbeliefs about design is imperative to the adoption of design approaches. One approach to better educate organizations on the purpose and benefits of design approaches is through examination of successful organizations that have adopted design approaches. Applying a design approach will add value to launching a CoP for programmers and developers with purpose.

B. WHAT IS DESIGN THINKING?

Design Thinking focuses on individuals' needs and the methods required to create something tangible and of value to an individual or an organization. Design Thinking builds on "creativity methods of the 1950s, and data science and design method movements of the 1960s" [57]. Author Herbert Simon explored "the notion of design as a way of thinking" in his 1969 book *The Sciences of the Artificial*, but the term *Design Thinking* did not emerge until "the 1980s with the rise of human-centered design" [57]. According to Robert Curedale [57], author of *Design Thinking Process and Methods,* the term Design Thinking was not used in design literature until 1987, when Peter Rowe,

author and contributor to the design field, released his book *Design Thinking* [57]. Over the past thirty years the term has evolved to incorporate ideas from numerous design methodologies and movements [57].

In the 1980s, revealed design began to focus increasingly on understanding the needs of users and organizations. Curedale documents how practitioners of Design Thinking began incorporating ideas from the user-centered design movement. In the 1990s, IDEO, an "award-winning global design firm," was among the founders of the design thinking movement [58]. Shortly thereafter in the early 2000s, a large personal donation was made to the Stanford d.school, which "pioneered the teaching of Design Thinking" [57].

Design Thinking is taught and used nationwide in both schools and communities. It often consists of three key tenets: empathy, collaboration, and accelerated learning [55]. Additionally, Design Thinking can be a valuable part of an innovation process [55]. At the Stanford d.school, the Design Thinking process "focuses on needs through finding, understanding, creating, thinking, and doing. At the core of this process is a bias towards action and creation: by creating and testing something, you can continue to learn and improve upon your initial ideas" [59]. IDEO uses Design Thinking to "bring together what is desirable from a human point of view with what is technologically feasible and economically viable" [58]. The following sections explore the three identified tenets of Design Thinking and their applicability to innovation.

1. Empathy

Design Thinking focuses on understanding the needs of users accomplished through research that uses empathetic approaches. In design, empathy may be defined as "identifying with others and adopting their perspective" [57]. Empathy is important because of the respect gained through observation and understanding of other's points of view and ideas. Empathetic approaches serve as both a "source of inspiration to the designer and aid in discovering user insights and unarticulated needs" [55]. Empathetic discovery may be accomplished through interviews, surveys, observations, and ethnographic methods to include: "watching, listening, discussing, and seeing in order to

better understand user needs" [55]. The purpose of empathetic approaches is not to persuade a group of individuals, but rather to seek and understand their point of view, and build trust. Trust built among users further encourages collaboration in designing a product suitable to the needs of all users.

2. Collaboration

The second tenet of Design Thinking, collaboration, helps organizations move toward "radical innovation, rather than incremental improvement, and seeks added value" in the design of a product [55]. Collaboration occurs between users and through the formation of teams or groups. Design Thinking combined with the added benefits of collaboration plays a valuable role in "unlocking new opportunities" [55]. Often "the best way to get a good idea is to get a lot of ideas," which often happens through active collaboration [60]. As highlighted in Chapters II and III, collaboration helps organize individuals to generate new ideas and share information to produces tangible results. Collaboration using a Design Thinking approach can help individuals unlock creativity, produce new ideas, and generate solutions to problems. Collaboration is an important part of creating an innovation, defined as "an adoption of new practice in a community" [61]. Collaboration is inherent throughout the innovation process, including sensing a community's concerns, envisioning what is needed to address those concerns, moving to adoption, and sustainment of a change.

3. Accelerated Learning

Collaboration may lead to accelerated learning through iterations of innovative visualization, experiments, and prototypes [55]. Accelerated learning is useful for proving useable feedback in order to assess the success of a design. In order to attain radical innovation through accelerated learning "the more experimentation the better" [55]. Additionally, quick and simple prototypes are ideal, because they provide rapid feedback in regards to implementation, resources need, funds, and development. One goal of accelerated learning through prototypes is to "fail quickly and frequently so that learning can occur" [55]. It is often recommended to "make simple prototypes and constantly test ideas as early as possible" throughout the design of something [55].

Prototypes should be used to guide and improve the design. Expectations should be made that change will need to occur throughout the phases of design. The key to accelerated learning is the Design Thinking framework that further supports the iterative cycle of prototypes, the innovation process, and the tools needed to achieve design of a product

The Design Thinking approach is iterative, not linear. Iterative processes are key to reducing risk of failure in addition to accelerating organizational learning [55]. As seen in Figure 2, this Design Thinking framework combines "classic creative problem solving with design methodologies" [59].

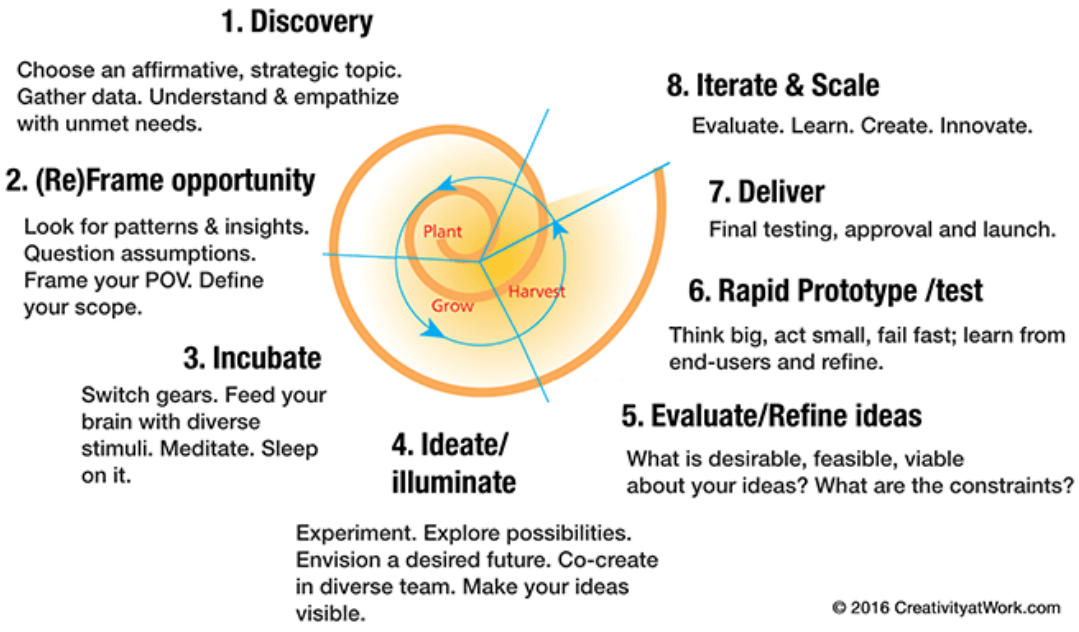

Figure 2. A Framework for Design Thinking. Source: [59].

This framework highlights the continuous nature of Design Thinking. Instead of a linear representation, it shows a repeating cycle of trials and approaches, to include prototypes and tests. Successful design will undergo multiple iterations and may revisit any phase of iteration as needed. The objective of this Design Thinking framework is "to make the intangible become tangible" [55].

Design Thinking presents a "very clear shift towards a more creative and more collaborative way of working—one in which intuition counts heavily, experimentation happens fast, failures along the way are embraced as learning, business strategy is integrated, and more relevant solutions are produced" [55]. Additionally, "Design Thinking is driven by intelligence that embraces innovation and gives an organization the freedom to explore multiple ways to solve problems – and discover the option that best delivers competitive advantage" [55]. Design Thinking creates and considers multiple options, refines selected courses of actions, and plans for their execution, while efforts remain focused on resolving problems through the use of design and test prototypes. Design Thinking is an approach that involves a "toolkit of methods that can be applied to different problems by cross disciplinary groups or by individuals" [57].

To help designers accelerate learning, Design Thinking utilizes a toolkit of methods to "define the problem and implement solutions, always with the needs of the user demographic at the core of concept development" [59]. Design Thinking is an "approach that supports innovation" [61]. It emphasizes "observation, collaboration, fast learning, visualization of ideas, rapid concept prototyping, and concurrent analysis, which ultimately influences innovation and strategy" [55]. The tenets of Design Thinking, empathy, collaboration, and accelerated learning, align with the key characteristics of successful CoPs, identified in Chapter III.

C. HUMAN-CENTERED DESIGN

Human-centered design is a "Design Thinking approach that is people-oriented" [62]. Human-centered design "started to evolve around the late 1990s" [62]. Prior to this, "human-centered design and user-centered design were often interchangeable terms regarding the integration of end users within a design process" [62]. Human-centered design author, William Rouse, describes human-centered design as philosophical: "Roles of humans in complex systems, enhancing human abilities, aid to overcome human limitations, and foster user acceptance" [63]. Over the past two decades human-centered design has "transformed from a method to a mindset, aimed to humanize the design

process and empathize with stakeholders, and further re-introduced Design Thinking as a mindset used for interpreting problems" [63].

The mindset of human-centered design is associated with "a deep understanding of the people for whom the product is intended" through means of observation [64]. As defined by Grant Young, international designer, human-centered design takes the "perspective of the end-users" and places their needs at the "center of the design process" [65]. Furthermore, a "human-centered approach fuels the creation of products that resonate more deeply with an audience—ultimately driving engagement and growth" [66]. In 2007, a MIT Business School study noted, "70% to 80% of new product development that fails does so not for lack of advanced technology, but because of a failure to understand users' needs" [67]. Therefore it is imperative to observe and understand the needs of users when designing something.

AirBnB and Pinterest are examples of successful companies that used design-driven approaches to promote and flourish in the business sector [66]. Their successes may be attributed to their focus on user needs, tailored website design to address these needs, and advertisement that targeted the intended audience in order to encourage participation, growth, and financial gains to further company success. In order to encourage customer feedback and support, the design approach must "cultivate a shared ownership of ideas, as new ideas are the team's idea, not an individual's" [66]. These approaches of shared ideas proved successful to AirBnB and Pinterest, which have used human-centered design approaches to further grow and sustain their businesses [66].

The mindset of human-centered design correlates to innovation, because of the shift in thinking from "me" to "we" when establishing the best possible solutions for solving a problem. Vijay Kumar, distinguished college professor, correlates "human-centered design to innovation, noting that in order to create innovations that have a good fit with users, the designer's focus needs to shift from products that people use, to what those people do—their behaviors, activities, needs, and motivations" [68]. The designers of IDEO agree, "Design Thinking is a human-centered approach to innovation that draws from the designer's toolkit to integrate the needs of people, the possibilities of technology, and the requirements for business success" [58].

In summary, human-centered design is “not about claiming credit, as no good idea comes from just one person, it is about the quality of the idea and success of the team” [66]. A human-centered design approach focuses on the needs of the intended audience, made through observations and inquiries [58]. In order to promote and encourage creative innovation among consumers, consumers must understand that their ideas and opinions are valued. Team focused approaches often encourage the free flow of ideas. A human-centered design approach is ideal for designing a CoP because its collaborative team-focused nature encourages innovative thinking by all of those interested in achieving the desired result.

D. A DESIGN-THINKING / HUMAN-CENTERED DESIGN APPROACH

Design Thinking coupled with human-centered design is people-oriented and focused on the needs of consumers. As described by IDEO CEO, Tim Brown, “Design Thinking provides an innovative approach that is human centered in an effort to solve problems based on the needs of the people at the center of the design” [58]. IDEO remains one of the leaders in human-centered design approaches, but other design consultancies occupy the same philosophical space.

The LUMA Institute, a “spin-off of the successful Pittsburgh-based design consultancy MAYA Design, has fully embraced the notion of design, design thinking, and human-centered design” [69]. The Institute “equips individuals, teams, and organizations to accelerate innovation” [70]. LUMA’s approach “is based on the use of techniques which communicate, interact, empathize, and stimulate the people involved, obtaining an understanding of their needs, desires, and experiences” [71]. The LUMA Institute promotes human-centered design training through workshops and training offered worldwide. Their handbook provides recommended tools and techniques that may be used for human-centered design.

The LUMA Institute [72] is an educational organization that provides designers with an assortment of tools and techniques so they may create purposeful and valuable products centered on the needs of users. The tools and techniques provided in the LUMA Institute handbook focus on methods associated with the key tenets of Design Thinking

to include: empathy, collaboration, and accelerated learning. As seen in Figure 3, their approach is composed of three phases: *looking*, *understanding* and *making* [72].

Figure 3. The LUMA Human-centered Design Approach. Source: [72].

The LUMA Institute human-centered design approach aligns with and simplifies standard Design Thinking processes by organizing into three phases and providing techniques to help designers understand how to progress.

1. Phase I—Looking

The purpose of the *looking* phase is "inquiry, analysis, and design through ethnographic, participatory, and evaluative research in order to identify the audience, purpose, goals, and vision for the community" [72]. These research methods may be conducted through interviews, observations, surveys, and activities. Traditional ethnographic research includes "participant and nonparticipant observation, focus on natural settings, use of participant constructs to structure the research, and investigator avoidance of purposive manipulation of study variables" [73]. Ethnographic approaches are "common in sociology and anthropology, but are used to some extent by all social

science disciplines" [73]. Ethnographic techniques are used to gather information through direct or indirect dialogue in order to obtain a holistic understanding of consumer needs. Ethnographic research further "develops empathy for the point of view of the user" [57]. One disadvantage of ethnographic research is that results are often "regarded as unreliable and lacking in validity and generalizability" [73]. Regardless, empathy is necessary because "in order to get to new solutions, you have to get to know different people, different scenarios, and different places" [74].

Designers use specific techniques in the *looking* phase to gather valuable information that helps them understand users' in their natural working environments. Recommended techniques encourage the designer to immerse themselves in the users' lives and practice, because of the insight gained from this in-context interaction [74]. Participatory techniques may involve potential community stakeholders in order to create and host activities that seek to "reveal individualistic thoughts and ideas, level of prioritization, key challenges, values, requirements, and opportunities for improvement" [72]. Participatory research is critical to maintaining creativity and energy among collaborating teams in order to refine the design process based on feedback [74]. Evaluative techniques and activities encourage non-attribution of inputs and ideas, while providing a forum for individuals to provide constructive feedback. One goal of the *looking* phase is to gather both subjective and objective feedback from consumers in order to better understand their needs, and incorporate this feedback into the overall design.

2. Phase II—Understanding

The *understanding* phase focuses on prototyping, which takes into consideration people, systems, patterns, priorities, and problem framing [72]. The tools and techniques provided in this phase aid in determining the key characteristics of successful communities as highlighted in Chapter III, to include identifying sponsors, structural designs, and strategies that aim for a sustainable lifecycle. Furthermore the *understanding* phase assists the designer in determining "the needs and goals of people, and methods to help identify benefits gained from this phase" [72]. It also provides the designer the

opportunity to “make sense of a vast amount of data, and identify opportunities for design” [74]. Furthermore, analysis of results from the looking phase may identify patterns and themes that can be used to design potential prototypes. Upon successive iterations of prototypes, a product may then be created.

Iterative approaches are key to solving problems because “it makes feedback from the people we’re designing for a critical part of how a solution evolves” [74]. Continuous iterations of prototypes allows for improvement and refinement of the work, and further provides opportunities to unlock creativity and arrive more efficiently to successful solutions [74]. Rarely is something designed correctly the first time. The *understanding* phase provides appropriate techniques to be explored in order to arrive at a solution for future adoption. The end goal of the *understanding* phase is to combine the collaborative efforts and innovative ideas, conduct successive prototypes, and create robust solutions for implementation into future designs.

3. Phase III—Making

The *making* phase focuses on the methods for envisioning future possibilities, including how to launch, grow, and sustain a community [72]. While the first two phases provide techniques and tools to better understand why something is being designed, the third phase is subjective and exploratory in the actual design. One way to design something is by examining previous successful examples from the same domain as the one currently being created. Another common approach to design is the use of checklists. This phase assists the designer in concept ideation, modeling and prototyping, and design rationale, but ultimately it is up to the designer as to how they *make* something [72].

The goal of the *making* phase is actual implementation of solutions. This is the part of the process where ideas get piloted. If throughout the design process, “the very people you were looking to serve were kept at the heart of the process” then in theory the solution will be a success [74]. As solutions are implemented, it is also important to consider designing a timeline or plan of action for sustainment of the design project. Successive analysis of solutions will need to be executed to evaluate if the solution is working or providing the results expected. This phase is when a designer further assesses

time, manpower, and funds needed to sustain the designed product. Finally, during the *making* phase, collaboration among designers, stakeholders, and members should occur in order to determine the desired end-state. These milestones will help "keep the design on course and give the team something to work toward" [74].

E. CONCLUSION

Design, Design Thinking, and human-centered design approaches inspire creativity and innovation, while providing designers with the tools and techniques to effectively design a sustainable and valuable product. These approaches focus on the deepened understanding of consumer needs and actions taken to create something that reflects this discovery. The process to obtain this desired end state is a developed empathy for users' needs, collaboration that inspires innovation, and prototyping through successive iterations and analysis. This thesis asserts that a design approach that utilizes Design Thinking and human-centered design is most appropriate for the creation of a Navy CoP for programmers and developers because of its focus on users' needs. Chapter V will elaborate on how the LUMA Institute human-centered design approach was implemented to make recommendations for launching and prototyping a Navy CoP.

V. DESIGNING A COMMUNITY OF PRACTICE FOR NAVY PROGRAMMERS AND DEVELOPERS

Design approaches can be used to create something with purpose and intent in order to solve a problem. Furthermore, Design Thinking and human-centered design approaches benefit from deepened empathy for users' needs in order to design something both tangible and of value to the users. Chapter V examines how the three phases of the LUMA Institute human-centered design approach (*looking, understanding,* and *making*) were implemented in order to make design recommendations to launch a Navy CoP for programmers and developers.

A. PHASE I—LOOKING

Following the LUMA's recommended techniques for the *looking* phase, ethnographic and evaluative research was employed to observe and discover users' needs. The author explored the techniques by taking advantage of the proximity and audience of HACKtheSKY, the U.S Navy's first hackathon focused on the practices of programmers and developers. A hackathon is an event where large groups of individuals meet in order to engage in collaborative efforts to solve problems [75]. During this three-day cybersecurity event interviews, observations, and surveys were conducted among consenting participants. Data obtained from this research were subsequently analyzed and in the *understanding* phase and recommendations for the design of a Navy CoP for programmers and developers are proffered in the *making* phase.

1. HACKtheSKY

The HACKtheSKY Navy hackathon was hosted by the Department of the Navy Office of Strategy and Innovation and the Naval Postgraduate School on June 24–26, 2016, in San Francisco, California at Galvanize, a startup incubator. The event theme was based on the world record set at NPS in 2015 for flying the largest swarm of drones ever controlled by a common code base [76]. The event included three different sub-events: Hackathon, Future of Autonomy Workshop, and Topcoder Rapid User Experience

(RUX) challenge. The hackathon was oriented toward programmers and developers, as well as user-experience designers, unmanned aerial vehicle hobbyists, and data scientists. The future of autonomy workshop was oriented toward technical and non-technical participants looking to help develop the autonomy roadmap for the Navy. The Topcoder RUX challenge mimicked the hackathon focus, but took advantage of a global audience in order to produce a larger pool of tangible solutions.

HACKtheSKY hosted a total of 220 hackers, coders, designers, data scientists, and developers from around the world over the course of three days [76]. The hackathon was open to all military (active duty and reserve), DOD, and industry civilians of all skill levels and interests. There were 17 organizations represented from the Navy, six from DOD, and 15 organizations and start-ups represented from the technology industry and academia [76]. Of the 151 on-site participants, there were 36 military personnel, 113 industry civilians, and two unaffiliated with any organization. Additionally, of the 151 on-site participants 133 were U.S. citizens, 16 non-U.S. citizens, and two of origins unknown [77]. HACKtheSKY provided a group of possible participants to observe while trying out techniques from the *looking* phase. Additionally, HACKtheSKY provided an opportunity to observe and interview programmers, developers, and Design Thinkers in their near-natural environments.

2. Ethnographic Research

One-on-one interviews and passive "fly-on-the-wall" observations were used to obtain a holistic understanding of participants' needs. Of those interviewed, half were active duty military and half were civilians from the technology industry. Of those participants from industry, several of them had prior military experience. Participants shared their experiences and thoughts in order to assist in better formulate ideas and concepts for how to best design a Navy CoP for programmers and developers.

a. Interviews

Interviews provide an opportunity to gather valuable information from individuals in order to better understand needs, desires, and opinions. Interviews conducted at HACKtheSKY were unscripted and often on the fly, with no pre-planned questions.

Interviews were held external to participant's day-to-day operations as to not affect work schedules. They were conducted one-on-one or as a group, which enabled dialogue and the free exchange of information between participants. The demographic of individuals interviewed included 75% Navy programmers and developers (officer, enlisted, civilian, and contractor) and 25% civilians. Of the active duty Navy participants, 23% of them worked as programmers or developers in cyber operations related billets, and the other 77% engaged in the practice as a hobby. Of the civilians interviewed, 66% of them worked in programmer and developer related jobs, and the other 34% engaged in the practice as a hobby. Of the active duty Navy and civilian participants, 29% performed in billets within the formal cyber workforce, 12% worked within industry, 59% were hobbyists, and 0% of participants were from the informal cyber workforce.

Interviews revealed a shared sense of need and support for a Navy CoP for programmers and developers. Interviews also provided the following ideas, concerns, and recommendations for the creation and design of a Navy CoP for programmers and developers:

- Participants expressed a strong need and desire to collaborate and bring together like-minded programmers and developers from the military, technology industry, and commercial sector.
- Participants' supported the idea of continued Navy-sponsored cybersecurity themed hackathons. Future hackathons should be challenge-driven instead of driven by operational needs, in order to encourage excitement and energy among participants.
- Face-to-face interactions help to build trust, share knowledge, and improve skills.
- Hackathons should encourage participation from individuals who are not necessarily programmers and developers, which would encourage the free flow of ideas and sharing of knowledge from a diverse spectrum of mindsets in order to solve real-time Navy problems.
- Future hackathons should be hosted in technology industry popular cities such as Seattle, Boston, or Austin, because of the diverse levels of expertise and concentration of programmers and developers in these areas who could help expand the boundaries of Navy cybersecurity practices.

- Military personnel should attend more hackathons offered throughout the technology industry in order to help individuals expand their social network and further develop and improve programming and developing skills.

- Further investigation should be made into existing programmer and developer communities (e.g., New Tech Seattle and VRhackathon) in order to understand how they remain effective and successful within industry.

In conclusion, the benefits of conducting interviews was the information gained directly from programmers and developers who wanted to share information, challenge preconceptions, and helped to deepen empathy for the challenges programmers and developers face in their work. Through one-on-one and group interviews, participants expressed a desire to expand the programmer and developer communities, including the formal and informal cyber workforces and industry. HACKtheSKY proved to be a success. Participants expressed desire for NPS to host future hackathons in support of collaboration toward creating solutions to military cybersecurity issues.

b. Fly-on-the-Wall Observations

Fly-on-the-wall observations, a LUMA-defined term and method, provide an opportunity to observe participants in an unobtrusive manner, while having the least amount of impact on the flow of participants' regular activities. This method allowed the author to pay careful attention to individuals' tasks and workflow, communication styles, and collaboration techniques. The author assumed the role of an objective bystander, continuously walking and roaming through both the future of autonomy and hackathon workspaces over the course of the weekend, while taking notes and making observations of both groups of participants. Overall observations include:

- The majority of participants exerted an energetic feeling and excitement expressed in their collaboration and conversations, which carried on throughout the weekend.

- Teams engaged in open collaborative conversations and appeared to encourage the free-flow of ideas. Furthermore, collaboration seemed to flow seamlessly within most teams.

- Design Thinkers were coached on how to present their ideas in a collaborative way, which was reflected in their energetic group participations. The hackers who were not coached on how to present, and while possibly not related, overall the hacker's gave less energetic presentations than those who were coached on providing effective presentations.

- The forum provided a useful venue to encourage innovative thinking in order to formulate more creative strategies to solve Navy problems. One participant stated that for their 35 years in the Navy, they were always told to think or stay in the box.

- Many participants were critical of the Navy's "archaic technology," and commented that the Navy could benefit from leveraging the latest technological advances of industry, and through collaboration and sharing knowledge with industry may improve Navy processes. They also made comments about the development of cybersecurity tools and their functionality in that it is often lacking within the DOD compared to the innovative developments found in the technology industry.

- The inclusion of students as young as mid- to late-teens in HACKtheSKY provided value to the community. These teenagers learned about how they could or might contribute to their nation by collaborating to solve Navy problems. Furthermore, it allowed them to expand their social network at a young age, which may attribute to continued interest and improvement in their programming and developing skills.

- It was valuable to expose programmers and developers to Design Thinking techniques in order to expand their knowledge and introduce new innovative ways of solving problems.

In summary, fly-on-the-wall observations provided thought provoking ideas to use for further analysis when developing recommendations for how to design a Navy CoP for programmers and developers. Future of autonomy and hackathon participants provided different mindsets and approaches to similar problems. This *looking* phase technique provided a method to observe participants in an unobtrusive manner, but still collect value insight from their daily interactions and collaborative efforts.

3. Evaluative Research

Surveys are one method recommended by the LUMA Institute handbook for how to conduct evaluative research in order to collect candid feedback from participants. Pre-drafted surveys were created and approved for use at HACKtheSKY. Pre-drafted surveys

included pre-hackathon and post-hackathon questions, as well research interview questionnaires focused specifically on the creation of a CoP for Navy programmers and developers. Furthermore, research interview questionnaires were divided into two categories (active duty military and non-active duty military), and distributed to consenting participants based on their identified affiliation as a programmer, developer, or Design Thinker. The surveys provided an additional source of documentation for the author's recommendations on how to improve processes and procedures.

The purpose of HACKtheSKY surveys was to solicit and crowdsource opinions, thoughts, suggestions, and critiques regarding a Navy CoP for programmers and developers, regardless of individual skill level. Thirty-one signed consent forms were collected. Of those thirty-one signed consent forms, sixteen participants completed requested surveys. Of those sixteen participants who completed surveys, 62% were active-duty military, 31% worked in the technology industry, 19% were veterans, and 6% were Navy reservists. (Note: there were no overlaps among these groups.) The following section summarizes survey results and highlights key takeaways. Appendixes A–D provide in-depth analysis of all four surveys, questions, and responses received.

a. Pre-hackathon Survey

The pre-hackathon survey consisted of fifteen questions. The intent of this survey was to collect demographic information about individuals attending HACKtheSKY, gain a better understanding of their self-assessed individual skill level as a programmer or developer, and insight as to what their expectations of the event were. Below are the summarized results from the pre-hackathon survey.

The vast majority of pre-hackathon survey participants consisted of active duty military officers, but also included several enlisted participants, and two civilians, each with approximately of nine years' experience as enlisted cryptologists. Collectively participants held some form of college education, but lacked formal military, civilian training, or education related to software and firmware programming and developing. Of those participants who completed this survey, only a third of them performed in programmer or developer roles within the Navy as part of their professional job within

the formal cyber workforce or industry. The other participants primarily engaged in the practice as a hobby. Regardless of this lack of training and education, over half of the participants claimed to be fairly skilled practitioners. The majority of participants reported having experience in common languages and repositories used by programmers and developers. This was the first hackathon that most participants had attended, and all had similar expectations going into the event to include: expand their social networks, improve personal coding skills, collaboration possibilities, and positively shape and improve Navy processes.

b. Research Interview Questionnaire (Military Specific)

The military research interview questionnaire consisted of fifteen questions. Nine participants completed this survey, of which two participants performed in a programmer or developer related job within the Navy's formal cyber workforce. The remaining seven participants engaged in the practice as a hobby. The intent of this survey was to gather information related to programmer and developer skills utilized within the Navy to gain insights on how the Navy might benefit from a CoP. Below are the summarized results from the military specific research interview questionnaire.

Most participants believed their specific skills were utilized in their current Navy job, but failed to identify whether or not these skills were related to the practice of a programmer and developer. Regardless, the majority of participants thought it was necessary for the Navy to invest and support the development of active-duty military programmers and developers. Furthermore, they believed that the focus of a CoP should be on Navy problems related to cyberspace. In addition to the necessity for Navy programmers and developers, participants did not believe the Navy should eliminate Navy civilian and contractor programmers and developers. Participants expressed a need for all three groups of individuals, because of the different levels of expertise and experience they provide which are necessary for solving Navy problems.

The majority of participants suggested that all officer and enlisted personnel throughout the Navy involved with cyberspace operations should have some basic programming skills, which would allow individuals to become more efficient in their

profession. Since computers are an essential part of maintaining critical DOD infrastructure, all service members should learn to take advantage of a computer's power. All participants agreed on the benefits gained from social and professional networking, along with collaboration.

Of the participants, few active duty personnel were currently serving in an official programmer or developer billet or role, increasing the criticality to expand social networks in order to improve the skills of our active duty personnel. As one participant stated:

> In general most problems are too complex for a single individual to accomplish, therefore they may require the assistance of other individuals to tackle the problem. As systems become more complex this will require a certain level of specialization that may prevent an individual from optimally solving all problems, therefore the collaboration and networking may be of value to that individual who lacks all the knowledge to effectively solve the problem. [Anonymous]

One of the biggest dilemmas that participants felt the Navy faced when retaining talented programmers and developers in the Navy was the pay scale differences between the military and industry. Participants agreed that financial incentives should be considered for military participants who have needed programmer and developer talent. There were different thoughts on how to evaluate the skill levels of programmers and developers.

Lastly, participants provided constructive feedback regarding the location of future CoP events. Recommendations were made to host more events in Navy or military concentration areas to minimize travel costs. In addition to location considerations, participants' recommend the Navy provide funding for both training and travel to related events and conferences.

c. Research Interview Questionnaire (Civilian Specific)

The civilian research interview questionnaire consisted of fifteen questions. Four participants completed this survey. Of the four participants, 50% were from the formal cyber workforce and the other 50% were from industry. The intent of this survey was to gather information about how individuals keep their skills proficient, if prior military

whether or not they utilized their programmer or developer skills while in the military, personal experience with CoPs, and their thoughts on a Navy CoP for programmers and developers. Below are the summarized results from the civilian specific research interview questionnaire.

Of the four participants from industry and academia, 75% had extensive military backgrounds, and all provided valuable feedback. All participants provided a spectrum of insights, despite their self-acclaimed lack of programming and development skills and expertise. All participants agreed that it is very important for programmers and developers to continuously collaborate, as the benefits gained may help break down barriers or inhibitors that exist between the U.S. government and industry. According to one participant, two of the largest barriers to establishing a Navy CoP for programmers and developers were the DOD acquisition processes and issues related to contractors and proprietary resources. They believed that the responsibilities, roles, and restrictions as outlined in the DOD acquisition process may blur the lines of how employees could contribute and interact within a Navy CoP. Therefore, they believed it would be helpful for the Navy to set boundaries on what the purpose, intent, and mission of a Navy CoP for programmers and developers should be.

While participants gave mixed views on their potential participation in a Navy CoP for programmers and developers, they all agreed it is necessary for the Navy to have skilled programmers and developers, and that the Navy could benefit from this type of CoP. A concern shared by a participant was the fact that Sailors are transient, working at any given command at any given time, which can lead to duplicated or lost work across organizations. Therefore, consideration must be given to enable dialogue and interactions among globally dispersed individuals.

d. Post-hackathon Survey

The post-hackathon survey consisted of fourteen questions. Thirteen participants completed this survey. Some participants did not complete this survey due to not attending the entire event, simply forgot to complete it, or felt they did not have any valuable feedback to contribute. Of the thirteen participants who did complete the survey,

23% performed in programmer or developer jobs, whereas the other 77% engaged in the practice as a hobby. Furthermore of those 23% who served in programmer and developer related jobs, two were from the formal cyber workforce and one individual was from industry. The intent of this survey was to gather feedback and recommendations on participants' experience at HACKtheSKY. What follows are the summarized results from the post-hackathon survey.

Overall, HACKtheSKY exceeded the expectations of participants with resounding support for future hackathons and social networking events. Participants believed that face-to-face interactions were vital to the development of a CoP for programmers and developers due to claimed benefits of a CoP as highlighted in Chapter II. Word of mouth and social media were reported as the two most popular means for how participants heard about the event. Participants left the three-day event with shared knowledge, expanded social and professional networks, trust with other participants, and a desire to continue supporting the Navy and its various missions! Furthermore, participants highly supported a combination of quarterly and semi-annual social interaction events. Some participants recommended utilizing the framework of existing successful communities explored in Chapter III, to include the Athena Project, MMOWGLI, and MCPA.

In summary, the *looking* phase of the LUMA Institute human-centered design approach allowed a deepened empathy for the undertaking of programmers and developers in order to gather subjective and objective feedback used to better understand their needs. Through simplified ethnographic and evaluative research techniques, participants were observed in the act of programming and developing cyber-related software, which allowed better understanding of user needs. Additionally, interactive non-attributional discussions provided constructive feedback, which proved important for further analysis, because "critical feedback is more effective when it is audible, credible, and actionable" [78]. The results from interviews, observations, and surveys will be further analyzed in the *understanding* phase in order to create recommendations for how a Navy CoP for programmers and developers might be designed based on user needs.

B. PHASE II—UNDERSTANDING

The *understanding* phase focuses on methods for analyzing information obtained from the *looking* phase in order to create actionable recommendations [72]. Results obtained from interviews, observations, and surveys conducted during the *looking* phase were further assessed in order to determine CoP design priorities based on user needs. Utilizing the People and Systems approach outlined in the LUMA method for the *understanding* phase, a Stakeholder Map was developed in order to identify potential sponsorship of a Navy CoP for programmers and developers [72].

1. Looking Phase Analysis

HACKtheSKY participants expressed the desire for NPS to continue hosting future hackathons to enable collaboration toward solutions to military cybersecurity issues. Participants provided candid and honest feedback that was valuable in developing recommendations for how the Navy could best design a Navy CoP for programmers and developers that is of value to users. The following is a list of assessments made based on interviews, observations, and surveys conducted during the *looking* phase:

- Through observations and comments made among participants, it is assessed that there is overwhelming support for the establishment of a Navy CoP for programmers and developers. Important takeaways from these observations include the need to communicate intent, empower people at the edges, and blend organizational doctrine and technology. It is further assessed that the Navy as a community needs to think in a different way and extend thoughts beyond normal traditions. Communities tend to grow more exponentially when individuals know why they are doing what they are doing, when there is increased emphasis on collaboration, and creative thinking is encouraged and accepted.

- There is a need for continued social interactions in order to build trust between members of a Navy CoP for programmers and developers. Interdependence and trust is built over time through collaboration and cooperation. Creativity and innovative thinking during events should be encouraged among programmers and developers. Additionally, it is important to highlight that failure is acceptable, and that we learn from our failures in order to formulate other creative ideas to produce better products and solutions.

- Despite a lack of formal training and education in programming and developing participants were well-educated and had a great depth of experience primarily due to being self-taught and motivated to excel in their practice. It is assessed that the Navy needs a guild for proper development of talent.

- Social interaction logistics should include the consideration of locations that encourage maximum participation from both military and civilian participants.

- Collaboration is key to increasing work productivity and mission accomplishment. There are perceived barriers that exists between the government and the technology industry that need to be addressed and taken into consideration when designing a CoP. Efforts should focus on making a CoP as inclusive as possible, in order to encourage the free flow of ideas from a diverse spectrum of individuals globally.

- Social interaction events provide value to both participants and the Navy, and depending on frequency can continue fostering community excitement and involvement. Continued social interactions would continue the growth of a shared repertoire of tools and knowledge, allowing members to further collaborate in order to take purposeful action towards accomplishing mission requirements. These resources may include tools, methods, lessons learned, databases, websites, or the use of anything that improves and/or provides content or relevancy to the practice of a CoP. Additionally, these projects may be in the form of meetings, conferences, or team building events such as formalized community challenges.

In summary, results from the *looking* phase provided constructive feedback for further analysis and assessments to be made in regards to how best design a Navy CoP for programmers and developers with the focus centered on the needs of users. In order to continue the design of a Navy CoP, potential sponsorship must be identified in order to further create and support the establishment of a Navy CoP for programmers and developers.

2. People and Systems

The developed understanding and empathy gained in the *looking* phase can lead to forms of innovation that can utilize this new knowledge in order to visually transcend and reinvent it. The Peoples and Systems approach is an array of techniques and tools the "support the ability to consider all kinds of people, places, and things in pursuit of creating a new value" [72]. One recommended technique that is of value in creating a

Navy CoP for programmers and developers is the creation of a Stakeholder Map, which allows individuals to visualize potential sponsoring organizations who might have a "vetted interest in the success and outcomes of a community" [72]. A Stakeholder Map includes potential sponsors, champions, and stakeholders who have interest in the practice of the intended audience and the outcomes that result from their profession. The creation of a Stakeholder Map should be intertwined with a team effort concept vice a one-sided design in order to observer all ideas and suggestions. The idea behind this technique is to "include a very broad range of sponsors, champions, and stakeholders, and strike a balance between breadth and relevance" [72]. The benefits from this technique include the identification and potential recruitment of sponsorship needed for support and the launch of a CoP in order to help guide plans for future prototyping, growth, and sustainment.

At this moment a Navy CoP for programmers and developers is an exceptional idea, but it needs the support from higher echelon commands to move forward. The author recommends that the Deputy Chief of Naval Operations for Information Dominance/Director of Naval Intelligence (OPNAV N2/N6) be the CoP sponsor, with support from subordinate commands. Establishing their presence and commitment as a sponsor will provide credibility and legitimacy to the continued promotion of a Navy CoP for programmers and developers. Once this relationship is established, critical items of interest such as mission and vision statements can start to be created.

As OPNAV N2/N6, they are responsible for the Information Warfare Community, and have a vested interest in utilizing the power of a Navy CoP for programmers and developers due to its strategic objectives [3]. In order to grow the formal and informal cyber workforces, there must be buy-in from the top down. This top-level support from OPNAV N/2/N6 may help seek out the most qualified personnel that currently have the talent, but no interest in joining the formal cyber workforce. Once these individuals are located, they can be introduced to the formal cyber community and asked to spread the word that the Navy is seeking to expand its cyber workforces. Additionally, the Navy has a great overall recruiting theme to maintain its manning levels, but such a campaign can

be utilized to create a much larger CoP by collaborating with the youth that will be our future.

As the sponsor, OPNAV N2/N6 would provide a Navy CoP with the legitimacy and gravitas needed to expand the reach of the community as was demonstrated in successful communities evaluated in Chapter III. OPNAV N2/N6 also has enough influence and authority to offer credibility for CoP events. OPNAV N2/N6 would be responsible for promoting the adoption of a Navy CoP for programmers and developers to senior ranking officials in order to recruit future sponsors and stakeholders such as the Chief of Naval Operations and Navy Type Commanders. While this support is not expected to be immediate, opening a continuous dialogue can start the process of designing and establishing a sustainable CoP for the long-term.

Tenth Fleet is the recommended champion for a Navy CoP for programmers and developers. Tenth Fleet carries credibility and legitimacy in their name and reputation throughout the military, academia, and industry communities. Tenth Fleet has the ability to channel into other networks in the military and civilian sectors. These channels may provide manpower or monetary support for future events, and the establishment of a Navy CoP for programmers and developers.

Figure 4 shows that the recommended stakeholders for a Navy CoP for programmers and developers should include the U.S. Navy system commands (SYSCOMs), Joint Task Force – DOD Information Networks (JTF-DODIN), and Tenth Fleet standing forces. The SYSCOMs make up the informal cyber workforce commands and are responsible for the “design, construction, and maintenance of military systems including ships, aircraft and weapons” [79]. The SYSCOMs recommended as stakeholders include Naval Air Systems Command (NAVAIR), Naval Sea Systems Command (NAVSEA), Space and Naval Warfare Systems Command (SPAWAR), Naval Facilities Engineering Command (NAVFAC), Marine Corps Systems Command (MCSC), and the Office of Naval Research (ONR) [79].

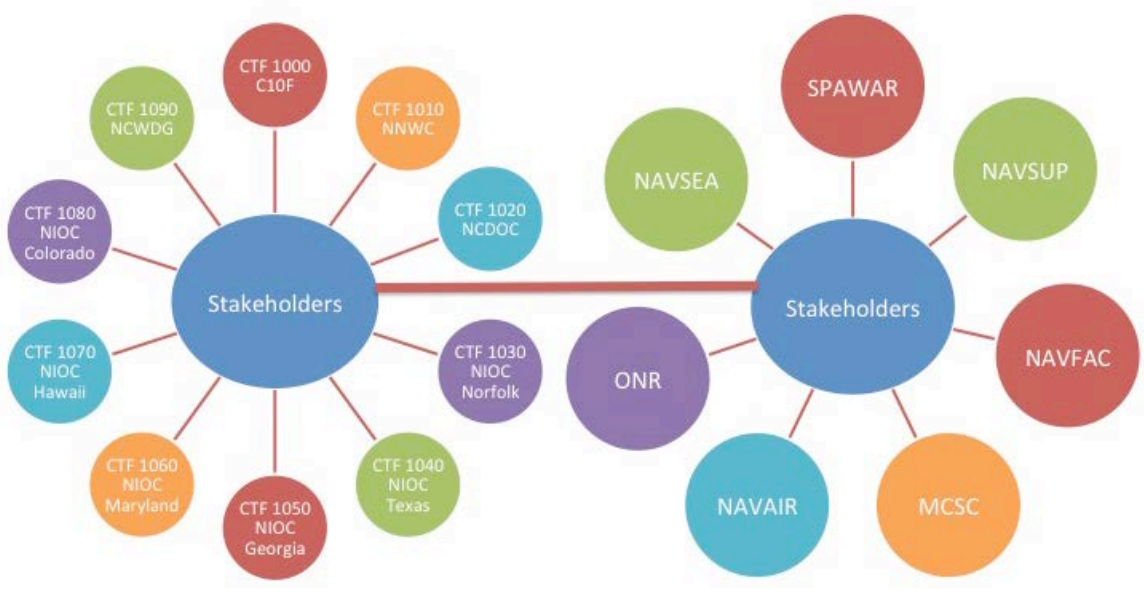

Figure 4. Recommended Stakeholders for a Navy CoP

The Tenth Fleet standing forces that make up the formal cyber workforce and are recommended as initial stakeholders include all Commander Task Forces (CTF) associated with Network Operations and Defense, IO, Service Cryptologic Component Operations, Fleet and Theatre Operations, and Research and Development, as well as Naval Information Forces (NAVIFOR). CTFs are identified by a four-digit number and command location. The following CTFs are included as recommended stakeholders: Fleet Cyber Command/Tenth Fleet, CTF 1000 (C10F), CTF 1010 (Naval Network Warfare Command), CTF 1020 (NCDOC), CTF 1030 (NIOC Norfolk), CTF 1040 (NIOC Texas), CTF 1050 (NIOC Georgia), CTF 1060 (NIOC Maryland), CTF 1070 (NIOC Hawaii), CTF 1080 (NIOC Colorado), and CTF 1090 (NCDWG).

These recommended stakeholders represent the respective forces and organizations that may help strengthen a Navy CoP for programmers and developers. Stakeholders should be focused on the general populace to include, civilian and DOD. A CoP would allow the Navy to utilize external experience and knowledge in latest technology and practices, which can ultimately improve Navy's current cyber operations. The civilian workforce operates under a different set of rules and regulations, which at times may provide its members additional flexibility to operate outside of normal

boundaries of Navy constraints. A CoP could assist industry in better understanding Navy restraints and constraints in order to develop tools and procedures to better assists in protecting key infrastructures. Collaboration and team building between formal and informal cyber workforces and industry equivalent may expand the Navy's cyber footprint globally.

All recommended sponsors, champions, and stakeholders may benefit from being involved in a Navy CoP for programmers and developers. Ideally, they should all have an interest in the accomplishments and goals of the CoP. All recommended sponsoring organizations (sponsor, champion, and stakeholders) represent personnel and organizations both within the Navy's formal and informal cyber workforces. This dynamic group of organizations may help in building relationships and bridges between these formal and informal workforces as well as with industry.

In summary, results of the *looking* phase interviews, observations, and surveys contributed to further assessments and the identification of potential sponsoring organizations in the *understanding* phase. The assessments and identifications examined in the *understanding* phase will be used in the last phase of the LUMA process, the *making* phase, in order to create recommendations for how to best design a Navy CoP for programmers and developers. Assessments bolster the support of the proposed Navy CoP due to the benefits to be gained as highlighted in Chapters II and III. Furthermore, with the identification of potential sponsoring organizations, focus can shift to the *making* phase in order to provide relevant design recommendations for a Navy CoP for programmers and developers.

C. PHASE III—MAKING

The *making* phase focuses on methods and approaches that can be used to effectively design a CoP for Navy programmers and developers. Through a series of brainstorming techniques, calculated risks in various methods of prototypes and innovation, and design rationale, the author created a generalized checklist that may be used to design any CoP. The checklist is broken down into the following categories as

defined by common key characteristics described in Chapter III: Social Interactions, Structure, and Lifecycle. Furthermore, Structure is broken down into the following sub categories as defined in Chapter III: 1) Sponsors, Champions, and Stakeholders, 2) Mission, Vision, and Purpose, 3) Membership Framework, and 4) Measures of Success.

1. General Guidelines

☐	CoP establishment should not be mandated. Use a "light hand" when creating the CoP. Otherwise members may be discouraged to join and participate.
☐	The CoP should remain simple and informal. If too many demands or expectations are imposed on CoP, then the focus shifts to satisfying the bosses' tasks, and further discourages CoP membership and participation.
☐	During the design phase of a CoP, the focus at all times should remain on the purpose for which the CoP is being created and designed. The primary focus should be for individuals to learn from each other as a result of shared knowledge and collaboration, while producing tangible results.
☐	Start small and evolve when designing a CoP. There is no rush to designing a CoP. Allow for the time to develop and prototype. The real useful action of a CoP is the interactions between members, not necessarily the technological means they have available.
☐	Remember that the idea of continuous CoP evaluation is that it offers the CoP team an opportunity to learn and reflect, with the understanding that it takes days, months, and years to design a successful CoP. Additionally, continuous assessment and re-evaluation on the return on investment of participation is key for determining commitment.

2. Social Interactions

☐	Are CoP champions assigned and designated in order to coordinate and plan social interaction?
☐	What is the annual projected social interaction plan?
☐	Is at least one of the annual social interactions a face-to-face interaction? If no, plan for at least one face-to-face interaction if possible, feasible, and affordable.
☐	Are social interaction problem statements and projects planned in order to produce tangible results?

☐	Are sponsors willing and able to host regional meetings and conferences in order to encourage the improvement and mentoring of member's practice?
☐	Have CoP members been informed on local community events that they may attend in order to seek mentors internal and external to their organization?
☐	What team-building events have been planned to include community challenges and encourage max participation?
☐	Are social interactions open to the public?
☐	Is there an established CoP website?
☐	Is the CoP website used to promote annual social interactions and events?
☐	Does the CoP website provide CoP members a forum to collaborate, network, and share knowledge, tools, and experiences?
☐	Are established after action reports and/or de-briefs planned post social interactions? Who has been assigned this task?

3. Structure

a. Sponsors, Champions, and Stakeholders

☐	Who are the recommended Sponsors? Note: May only have one Sponsor.
☐	Who are the recommended Stakeholders?
☐	Who are the recommended Champions?
☐	Do all sponsors, champions, and stakeholders respectively provide credibility, legitimacy to the CoP?
☐	Do sponsoring organizations support and have a vetted interest in the CoP?
☐	Do sponsoring organizations know how they will benefit from and contribute to the CoP?

☐	Are sponsoring organizations willing to remove barriers and obstacles that may prevent CoP productivity?
☐	What previous experience do sponsoring organizations have with current or existing CoPs? Do they understand their current roles and responsibilities within the CoP?
☐	How should the sponsoring organizations interact with CoP members, and how frequently should these interactions occur?
☐	Are sponsoring organizations capable of providing the necessary infrastructure and/or support as needed by CoP?

b. Mission, Vision, and Purpose

☐	Are mission and vision statements short and concise?
☐	Are mission and vision statements publically displayed for all current and future members to view?
☐	Did sponsoring organizations provide input in regards to CoP mission, vision, and purpose?
☐	Do the mission and vision statements align with the goals of sponsoring organizations and their key issues?
☐	Does the CoP have focused and well-defined purposes? Where can these purposes be found?
☐	Are the purposes publically displayed for all current and future members to view?
☐	Do the purposes reflect and include learning through shared knowledge, collaboration, and the acts of taking purposeful action in order to successfully execute tasks and projects?
☐	Do the purposes highlight member benefits gained from active CoP participation?

c. Membership Framework

☐	Who is the intended audience for the CoP?
☐	Is CoP membership inclusive?

☐	Is CoP membership volunteer based?
☐	Does the CoP website include a list of potential benefits gained from being an active member within the CoP?
☐	Does the CoP website inform current and future CoP members suggestions on how they may contribute or add value to the CoP?
☐	What costs might be incurred by the CoP in order to afford the opportunity for CoP members to effectively social network and collaborate?
☐	What is the current assessment and re-evaluation plan for determining the return on investment of participation in a CoP?
☐	How is membership commitment to the CoP determined?

d. Measures of Success

☐	Have sponsoring organizations provided input in regards to what they think a successful CoP may look like?
☐	Is there an established guideline or checklist for post-event assessment in order to measure the success of an event?
☐	What is the plan of action for assessing how the CoP is progressing?
☐	How might we assess the level of trust earned and developed between and among CoP members?
☐	Have pre and post surveys been created for events in order to evaluate events and received candid feedback, suggestions, and recommendations for how to improve future events? Are these surveys non-attributional?
☐	What metrics are best for measuring success of the CoP?

4. Lifecycle

☐	How often will the lifecycle of the CoP be assessed?
☐	Are interested sponsoring organizations involved in lifecycle assessment planning meetings?
☐	What is the plan for post social interaction assessment meetings in order to evaluate event feedback, number of members, frequency among member

	collaboration, and future planning?
☐	What available means are there for evaluating the lifecycle of the CoP? Note: Teleconferences may accommodate a larger audience in order to receive more input from sponsoring organizations.
☐	What are the levels of energy, commitment, and visibility within the CoP?
☐	Is it recommended that a certain phase be repeated in order to potentially re-design, prototype, or launch a new idea?

This checklist is one recommended tool for how a Navy CoP for programmers and developers may be designed. This checklist was created with specific focus on key characteristics within successful CoPs, and is therefore not inclusive of all possible CoP characteristics. As with the LUMA Institute human-centered design approach and handbook, any step throughout this checklist may be skipped if it is not applicable to the design the CoP.

D. CONCLUSION

The LUMA Institute human-centered design approach provides a framework for incorporating and analyzing feedback, suggestions, and recommendations on how to design a Navy CoP. Results from the *looking* phase collected from a diverse collection of military and civilian participants at HACKtheSKY provided insight into an expressed desire and need for a Navy CoP for programmers and developers. Analysis of these insights in the LUMA *understanding* phase shed light on specific points of concern when designing a CoP, to include potential membership, levels of contribution, benefits, and recommendations for future CoP social interactions. Finally, in the *making* phase these considerations and key characteristics were coalesced to develop a specific set of check points in order to launch a CoP tailored to user needs and desires.

Chapter VI ties in supporting evidence from previous chapters and insights gained from implementation of the LUMA Institute human-centered design handbook in order to provide specific actions recommended for Tenth Fleet, the proposed champion and chief

organizer of events, to initiate the establishment of and future launch of a Navy CoP for programmers and developers.

VI. CONCLUSION AND RECOMMENDATIONS

The main research objective of this work was to explore how the Navy may benefit from a CoP for programmers and developers.

The Navy stands to benefit from the creation of a CoP for programmers and developers sponsored by the formal cyber workforce because of the tangible benefits gained. Overall CoP benefits include expanded social boundaries, shared knowledge, and a shared repertoire of tools and resources that may be used to improve how organizations execute and accomplish missions. Expanded social boundaries enable dialogue between a diverse global spectrum of individuals, which may unlock innovative creativity, and through collaboration capture and diffuse knowledge in order to deliver tangible results.

These benefits are often due to the structural ways that CoPs invite and merge diverse groups of individuals together in order to collaborate on solving a problem. The establishment of a Navy CoP for programmers and developers provides bi-directional tangible benefits to the formal and informal cyber workforces and industry. Benefits include global access to all levels of expertise, mentorship, connectedness, increased cybersecurity of computer dependent systems, exposure to the cybersecurity needs and requirements of the Navy, and exposure to the latest and greatest technology, tools, and techniques found in industry.

Furthermore, a Navy CoP for programmers and developers should have the features, tools, or characteristics of GitHub, Stack Overflow, and Top Coder. These features include: a global community organized around a certain domain identity that advocates developers act as change agents; incentives for interacting, mentoring, and coaching; and competitions that provide incentives that encourage collaboration to produce tangible results. These benefits are often attributed to the structural elements of a CoP. These elements are defined by key characteristics shared among successful CoPs.

Key characteristics of successful CoPs should be taken into consideration when exploring design approaches and techniques for creating a CoP. Various forms of social

interactions are important to building relationships and developing trust among members in order to encourage continued active participation within the CoP. Social interactions would only promote and maintain the stamina of a new CoP for so long until the CoP needed credible and legitimate support from sponsoring organizations. Therefore it is important to identify and establish sponsors, champions, and stakeholders that have a vetted interested in the success and outcomes of the CoP early on in the creation of the community. Once sponsoring organizations are established, they can assist in the development of the mission, vision, and purpose of the CoP. These statements should be accessible to all interested parties in order to recruit and promote an inclusive membership framework, that is centered on shared identifies of members' practice. This sense of identity may foster continued commitment to the success of the CoP, and may also be used to measure success.

Furthermore, a Navy CoP for programmers and developers should have the shared characteristics of existing successful communities to include: Athena, Black Hat, Def Con, APAN, MMOWGLI, and Company Command. These characteristics include: small and large scale face-to-face events; a virtual space designed and hosted by DOD that enables collaboration across communities within the Navy and DOD as well as between the public and private sectors; inclusive membership; and clear measures of success. All of these characteristics factor into the lifecycle of a CoP and should be taken into consideration when designing a Navy CoP for programmers and developers.

Design approaches and techniques often focus on end results influenced by users' needs and encourage collaborative thinking among vastly dispersed groups of individuals in order to design something with intent and purpose. Furthermore, a human-centered Design Thinking approach "puts the needs of users at the center of the design process," and through observations and collaboration encourages innovative thinking of all involved in order to design the best possible product [66]. The LUMA Institute human-centered design approach simplifies Design Thinking processes into three simple phases: *looking*, *understanding*, and *making*. These phases are conducted through interviews, observations, surveys, stakeholder maps, and design checklists in order to produce the best solution based on user needs.

In conclusion, a Navy CoP for programmers and developers has the potential, if designed purposefully and given the time to mature, to enrich the body of knowledge and practice of cybersecurity and cyber operations for programming and developing software of consequence to the service. However, a successful CoP is not created overnight. CoPs take time to "emerge, to flourish and to become productive" [9]. It may take a series of iterations and innovative prototypes to find what does and does not work. Therefore, time, patience, and prototype will be necessary to further design a Navy CoP for programmers and developers in order to reap the claimed benefits of a CoP.

A. RECOMMENDATIONS FOR TENTH FLEET

The author recommends Tenth Fleet, as the recommended CoP champion and chief organizer of CoP events, be ultimately responsible for the supporting, prototyping launching, and growing of the proposed Navy CoP for programmers and developers. As seen in Figure 5, this thesis research made an assumption that the Navy would benefit from the design of a Navy CoP for programmers and developers, it inquired about the benefits of the proposed CoP, proposed design techniques and approaches, and conducted minimal prototyping. Chapter II and Chapter III inquired the benefits and characteristics of CoPs. Chapter IV discussed design approaches and techniques to use when designing a CoP. Chapter V implemented the LUMA Institute human-centered design approach and tested *looking, understanding,* and *making* techniques in order to make further recommendations for prototyping and future design of a Navy CoP for programmers and developers. At this point, it is recommended that Tenth Fleet become responsible for the continued prototyping and ultimately launch the CoP in order for it to grow and sustain as a living entity.

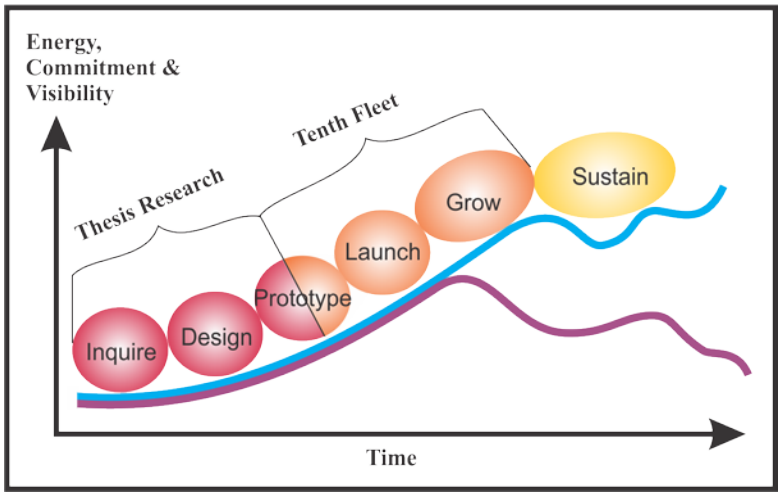

Figure 5. Community of Practice Lifecycle Phases. Adapted from [14].

We believe that the Navy will benefit from a CoP for programmers and developers. Through the work provided here, Tenth Fleet is provided with recommendations based on literature review and characteristics of existing communities for how to best design a successful and sustainable CoP for programmers and developers. Below are specific actions that are recommended to support, adopt, and see through to completion in order to initiate the establishment of a Navy CoP for programmers and developers. These recommendations took into consideration all literature review, examination of existing successful communities, and recommendations received through the use of surveys, questionnaires, interviews, and observations obtained utilizing the LUMA Institute human-centered Design Thinking approach.

1. Social Interactions

The Navy formal cyber community should conduct quarterly social interaction events. Two of these quarterly events should be face-to-face interactions, specifically semi-annual hackathons, given the importance of establishing trust and repertoire within and among CoP members. In addition to semi-annual hackathons, we recommend that members of the CoP determine the other two quarterly events. Planning and preparation for a hackathon is both time consuming and costly, therefore the other two events should be inexpensive and require little time to design and host. Some suggestions received from

survey feedback were to conduct Athena Project-related events in Navy concentration areas. Given the diversity and number of Athena groups located throughout the Navy, potential Athena members could volunteer their time to coordinate with sponsors and stakeholders on hosting a programmer- and developer-related Athena Project event. This would also provide a platform for Sailors to pitch their cyber-related ideas that could potentially be used for future hackathons. Additionally, this approach could potentially recruit more membership participation from within the formal and informal cyber community, therefore expanding the Navy's cyber workforce.

In the subsections that follow, some mechanisms for social interactions are described. They include semi-annual hackathons, an online web presence, and cybersecurity conferences.

a. Semi-annual Hackathons

HACKtheSKY was a success, and positive feedback was received from all participants, as well as the desire and interest to continue similar face-to-face interactions. Hackathon locations should move from key cities to key Navy concentration areas, in order to draw maximum participation from the Navy and industry. The first hackathon was conducted in San Francisco, but feedback received supported the following locations for future hackathons: Austin, Boston, Seattle, San Diego, Hawaii, and Washington DC.

A second hackathon, HACKtheMACHINE, is being planned for Austin, Texas in February 2017. It is recommended that a third hackathon be located on a military installation, preferable a location that has large platform ships and/or aircraft. Hosting a hackathon on a military installation, especially Navy installations, can be motivation for industry to further participate and engage in the establishment of a Navy CoP for programmers and developers. Though the hackathon, industry participants may gain a deeper understanding of the needs and requirements of the Navy.

The CoP champion should ensure that all hackathons have appropriate resources. This may include travel and accommodations for a designated number of active duty military participants. A Tenth Fleet organization provided such support to HACKtheSKY, and it was an incentive for military personnel to participate. Sponsors

and stakeholders should also provide input for hackathon projects. The CoP champion should take the lead in polling all potential stakeholders for project ideas, and use those as a guideline for how to advertise and recruit for future hackathons. Investigation of the most effective format for a CoP hackathon should be conducted.

b. Online Web Presence

An online web presence that would allow CoP members to collaborate and share knowledge should be considered. Support for a web presence was echoed in all surveys received from HACKtheSKY participants. The purpose of an online web presence would be to post information pertaining to future CoP events and activities, as well as provide a place for the free flow of ideas and collaboration, questions and answers, and shared knowledge.

Due to the inclusiveness of membership, it is recommended that a group site be established and created on APAN, which is an "unclassified information sharing service for the U.S. DoD" [37]. The author could create the initial group site with the assistance of HACKtheSKY participants. Those participants could provide feedback and inputs in regards to design and functionality of the website. The website should be maintained for at least one year in order to evaluate its usefulness and purpose. One way to measure its usefulness may be to survey registered users and ask for their feedback. The website might also provide various metrics for measuring success. If after a year, the website does not prove to serve a purpose or fails to be used by CoP members, then trying a different website such as that of MCPA, which already has an established cyber presence, should be considered. Regardless of the website chosen, the primary objective for its purpose and functionality is to meet and address the needs of CoP members.

c. Cybersecurity Conferences

Sponsors and stakeholders should encourage interested service members from the formal and informal cyber workforces to become actively involved with local cybersecurity conferences. These conferences provide benefits such as social networking, sharing knowledge, and improving basic skills. It is recommended that the formal cyber community promote participation by service members in addition to logistic support to

cover the costs of travel and conference expenses. Policy changes should be made that incorporate attainable goals for how Sailors can become more proficient programmers and developers, with cybersecurity conference attendance and participation being one solution. These goals should not be mandated or required, but should serve as tools and suggestions for how Sailors may be more proactive in becoming proficient at their practice. Additionally, guidance should be given to Sailors on how these conference may benefit them professionally and personally, as well as how they can mentor and teach others who were not able to attend as a way of giving back to the community and CoP at large.

2. Structure

CoP sponsors, champions, and stakeholders must first be identified and agree to assume the roles and responsibilities of their title before other structural elements of a CoP are addressed and developed. Once sponsoring organizations have been identified, actions may then be taken to establish mission, vision, purpose, membership framework, and measures of success. In combination, these elements can create the foundation for the design of a successful CoP. Chapter VI recommended that OPNAV N2/N6 be the CoP's core sponsor, Tenth Fleet the CoP champion, and U.S. Navy system commands (SYSCOMs) and Tenth Fleet standing forces would be the recommended stakeholders for a Navy CoP for programmers and developers. All recommended sponsoring organizations represent personnel and organizations both within the Navy's formal and informal cyber workforces, and should have an interest in the accomplishments and goals of the proposed CoP. This dynamic group of organizations may help build relationships and bridges between these formal and informal workforces as well as with industry.

a. Mission, Vision, and Purpose

Sponsoring organizations and CoP members have valuable ides and insights that may contribute to determining appropriate mission, vision, and purpose of a Navy CoP for programmers and developers. It is recommended the CoP host a design event in order to crowdsource ideas for simple, but often time consuming tasks, such as determining mission and vision statements, purposes, benefits, and CoP membership guidelines. A

design event could help promote further membership by using the ideas and solutions created by innovative participants. Furthermore, the design event could also focus on the CoP web presence, and how to best design an active webpage that meets the needs and desires of CoP members. Tenth Fleet should be responsible for the organization and logistics of this event. A MMOWGLI call to action may be a way to crowdsource a large diverse audience to generate design ideas.

b. Membership Framework

Membership should be inclusive and focus on the establishment of CoP member commitment. Providing incentives to active participating members often encourages membership commitment. Two cost efficient ideas to further commitment of potential CoP members are reputation points and a repository of programmer and developers tools. These incentives have the potential to increase commitment and further the development and proficiency of their skills.

It is recommended that the CoP develop a reputation system similar to Stack Overflow, stackoverflow.com [17]. A reputation system may be implemented as a feature on a webpage used by the Navy CoP for programmers and developers. As demonstrated by Stack Overflow users, reputation points may encourage members to take a more active role to improving their practice and that of others. Furthermore, the importance and value benefited from focusing the design of a CoP on competition *and* community may further increase active participation. Additionally, reputation points or awards may be implemented through attendance, participation, and winning hackathon events. A reputation system is one form of incentive that could easily be adopted as a characteristic to a Navy CoP for programmers and developers, and simply integrated into the operational structure of the CoP.

It is recommended that Tenth Fleet develop a repository of programmer- and developer- related knowledge and training that is available for Navy personnel who wish to become more proficient in their practice. Further research is needed to determine the cost of establishing such a repository. This repository could also be featured on the CoP's webpage. CoP members should eventually take ownership of this database in order to

share knowledge and create new knowledge. Initially this website should be unclassified, to allow access to all CoP members. This repository could highlight readings and trainings that are particularly relevant to current cyberspace operations or cybersecurity, as a means for practitioners to become more proficient.

c. Measures of Success

Once sponsoring organizations have been established, a regularly scheduled quarterly teleconference of all interested parties should be established to generate a guideline for measures of success. These measures of success will be necessary for the evaluation of the CoP, and may indicate when changes and adjustments are needed to improve the design of the CoP. Determined measures of success should be used as guidelines, and can be tailored to the event or interaction being evaluated. Measures of success may include assessment checklists, or surveys that can be used before and after the completion of social interaction events. It must be reiterated that these should be guidelines and not formal procedures, due to the drawbacks of using a heavy hand in the design of a Navy CoP. CoPs have natural lifecycles and may need to be left alone in order to flourish. Often CoPs need minimal support and guidance, therefore guidelines are only recommended tools that can help in determining the success of the CoP but also allow for the natural development, growth, and design of a CoP to take place over time.

3. Lifecycle

It is important to continue prototyping various methods of social interaction in order to find out what does and does not work for designing a Navy CoP for programmers and developers. Prototypes already mentioned include quarterly social interactions and design events that take advantage of the diverse mindset of individuals stationed and located throughout the world. Furthermore, it is recommended that stakeholders conduct post-event assessments in order to determine their level of success and influence in CoP promotion and development. Furthermore, it is recommended that semi-annual meetings be held to include the CoP sponsor, champion, and stakeholders in order to address the lifecycle of the CoP, and determine what stage(s) need to be revisited in order to continue growth and momentum.

B. AREAS FOR FURTHER RESEARCH

This research demonstrated the need to conduct iterative prototypes in order to design a successful CoP. Feedback received from HACKtheSKY participants reflected a shared desire for establishing monetary incentives for keeping programming and developing skills of military members proficient. Possible further research on this topic is described in the sections that follow.

1. Iterative Prototypes

Additional prototypes are needed in order to determine the forms of social interactions needed to build membership commitment and ensure the longevity of the CoP. Throughout the design of a CoP, opportunities will arise to test prototypes and run several iterations of each prototype, but as pointed out previously, this will take time. As CoPs take time to design and cultivate. These processes cannot be forced, and should remain inclusive, yet frequent enough to encourage and maintain interest and participation. Successful CoPs go through several design iterations and any part of the design process may or should be revisited in order to find what works best for the CoP. Therefore it is imperative that invested members of the CoP perform continuous assessments on the progress of the CoP design and determine which prototype to implement in order to design a more sustainable and effective CoP.

2. Incentives

Further research should be conducted in regards to the cost and benefits analysis of implementing a monetary incentive program for programmers and developers to keep their skills proficient. A monetary incentive should include yearly testing to initially establish and then later on evaluate skill level and proficiency, similar to that of DOD language skills. Furthermore, policy would need to be established in order to properly evaluate how skills are determined. One recommended self-accessed adult skill acquisition scale is the Dreyfus model, which consists of five skill acquisition levels: “Novice, Advanced Beginner, Competent, Proficient, and Expert” [80]. The Dreyfus model was implemented in surveys for HACKtheSKY in order for participants to self-evaluate their skill levels. There is limited literature that supports or discourages the use

of this tool; however, it is one method to utilize in determining the skill level of Navy programmers and developers.

C. SUMMARY

Instead of formulating an end goal, opening the discussion about a CoP was the author's end goal of this research. Extensive research and literature review was conducted, in addition to minimal prototyping. What emerged from this initial design phase was a further need to continue designing the CoP. We are confident that such work will be beneficial to the formal and informal cyber workforces and the Navy at large. This research has provided recommended tools and processes for how to design a successful CoP, but leaves the potential for future researchers to expand on prototypes and the adoption of a CoP based on established principles and policies. Further research will increase the Navy's situational awareness, and inform decision makers in determining how to design an effective, successful, and sustainable Navy CoP for programmers and developers.

This thesis research made the initial assumption that the Navy would benefit from a Navy CoP for programmers and developers. The research demonstrated the importance of replication and implementation of key characteristics found in successful existing communities when designing a Navy CoP for programmers and developers. It is imperative at this point in the lifecycle phase of designing a CoP to take necessary steps and immediate actions in order to establish a Navy CoP for programmers and developers. Both long term and immediate recommendations were provided on how to design this CoP.

When designing a CoP senior leaders need to be mindful of the patience required for the cultivation and prototyping needed for the creation of a successful CoP. Furthermore, the Navy should not rely on excessive measures of success, and allow the development of a CoP to naturally happen over time. Literature and feedback from HACKtheSKY participants' echoed the same concern, that if the Navy focused too much on excessive metrics, then this would deteriorate the nature of the CoP. Members would

be less likely to want to be involved in the CoP if they knew the Navy was more concerned about metrics then allowing the CoP to develop on its own overtime.

Recommendations for the next lines of effort in the design of this CoP is establishing an online presence in the form of a CoP website, determining and recruiting sponsorship, promoting the community, and further prototyping in order to determine what does and does not work. Upon completion of several iterations, the author is confident that the Navy will reap many benefits unknown at this time that will come from expanding its boundaries in the domain and practice of programming and developing.

APPENDIX A. PRE-HACKATHON SURVEY

The pre-hackathon survey consisted of 15 questions. The intent of this survey was to collect demographic information about individuals attending HACKtheSKY, gain a better understanding of their self-accessed individual skill levels as a programmer or developer, and hear what their expectations of the event were. Listed below are the results from the pre-hackathon survey:

(1) Question 1: Male or Female?

- Ninety two percent of the participants were male, and 8% were female.

(2) Question 2: Current Job Title/Description?

- Job titles and descriptions included Midshipman, Intellectual Property Specialist, Network Forensics Technical Director, Commanding Officer, Head of Data Science, Project Manager, Developer/Operator, Operations and Training Staff Officer, Cyber Operations Officer, Commander's Innovation Group Member, Cryptologic Warfare Officer, and Naval Innovation Advisory Council member.

(3) Question 3: If Active Duty Military or Reservist: Rate/Rank and Time in Service (years)?

- Fifty six percent of participants were active duty military and 6% were reservist. Collectively, the group contained over 193 years of military service. The military ranks of participants ranged included Enlisted (E-6) and Officer (01-05).

(4) Question 4: If Military Veteran: Rate/Rank and Time in Service (years)?

- Nineteen percent of the participants were military veterans. The highest Officer rank earned was the pay grade of Commander (O-5), and the highest Enlisted rank earned was the pay grade of First Class Petty Officer (E-6). Collectively, the military veterans had approximately 45 years of combined military service.

(5) Question 5: If Active Duty Military, Military Reservist or Military Veteran – Designator at entry?

- Of the 56% military participants (active-duty, reservist or veterans), 50% were Cryptologist. Designators included Cryptologic Technician

Networks, Engineering Duty Officer, Intelligence Officer, Surface Warfare Officer, and an Aviator.

(6) Question 6: Do you have any college level degrees related to Computer Science, Engineering, or Programmer/Developer skills? If so, what level of degree and in what field?

- Thirty three percent of the participants had college level degrees related to Computer Science and/or Engineering. Sixty three percent of all participants reported having obtained a Bachelor of Science degree or higher. Degrees obtained included: Mathematics, General Science, Systems Engineering, Mechanical Engineering, Information Technology, and Physics. Several individuals had Master level degrees in Astronautical and Aerospace Engineering, and Cyber Systems and Operation. Two participants had Doctorates in Physics and Electrical Engineering. Two participants are currently pursuing Bachelor of Science degrees in Cyber/Information Security and Cyber Operations.

(7) Question 7: Do you have any formal military and/or civilian education related to programming/developing? If so, what type of training?

- Eight percent of participants reported having 400 hours of advanced programming training and completing a Computer Network Operations internship. Collectively the group had minimal to no formal military or civilian education in relation to programming and developing, aside from those who had or are pursuing cyber related degrees. Most experience came from college class work associated with a computer science related degree.

(8) Question 8: How do you assess your current programmer/developer skill level?

- To define skill levels, the author used the Dreyfus model, a model used to rank and access adult skill acquisition [80]. The Dreyfus model includes five skill levels: Novice, Advanced Beginner, Competent, Proficient, and Expert [80]. There are certain criteria met that defines an individual's skill level, but more often than not individuals self-define and evaluate their own skill levels. Of the 14 participants who completed this particular survey, 33% claimed to be a novice, 7% advanced beginning, 26% competent, 33% proficient, and no experts.

(9) Question 9: What languages do you currently use and/or prefer?

- Fifty percent of participants use and/or prefer Python, 29% 'C', 14% JavaScript and C++, and 7% PHP, Haskell and MATLAB.

(10) Question 10: Do you have any experience or currently use any particular repository or collaboration platform?

- Fifty seven percent reported experience with GitHub, 43% Slack, and 21% SourceForge.

(11) Question 11: Are you currently a member of any formal or informal Community of Practice? If yes, what is the name and nature of the community?

- Thirty three percent of participants are current members of a CoP. CoPs listed included: Naval Constellation, Navy Entrepreneurship, Cyber Warfare Engineers, Navy Uniformed Software Development, Ideation CoP (OSD Design Thinking), Defense Entrepreneur's Forum, Military Writer's Guild, Innovation Entrepreneurship, and the ATHENA Project.

(12) Question 12: Is this your first time attending a hackathon? If no, what previous hackathons have you attended and what was the overall project?

- For 58% of participants, this was the first hackathon they had ever attended. Some of the participants (25%) had previously attended the United State Naval Academy's Hack the Yard hackathon earlier this year, which consisted of various cyber and computer science related projects.

(13) Question 13: Do you prefer to be on a particular team, or are you open to being paired with a team of our choosing based on skill sets and languages in order to encourage collaboration? Teams will consist of 3–5 individuals.

- Sixty seven percent of participants would have preferred to be on a random team, and 17% preferred a specific or pre-selected team.

(14) Question 14: What do you expect to gain from attending this hackathon?

- The two most common answers received were to meet like-minded individuals and social networking opportunities. Other responses included: improve skills, available learning opportunities, building relationships with national security interested individuals, networking opportunities external to service, developing relationships, exposure to software design and prototyping, gain better knowledge of coding, learning how to collaborate in a hackathon environment, explore how hackathons might be used to solve military problems, and impact traditional methods for advancing naval capability.

(15) Question 15: If you have any further comments, or information that you think would be of value, please share here.

- Participants provided no additional comments or information.

APPENDIX B. RESEARCH INTERVIEW QUESTIONNAIRE

There were two different research interview questionnaires were distributed to consenting participants. One questionnaire was designed for active duty military. All other questionnaires were designed for civilian participants. Participants were provided the survey that aligned with their registration information, and whether they identified as a military or civilian participant. For those participants that did not identify or provide this information during registration, they were emailed both questionnaires and asked to fill to the one more closely related to their current job and position.

Military Research Interview Questionnaire

The military research interview questionnaire consisted of 15 questions. There were nine participants who responded to the questions in this survey. The intent of this survey was to gather information related to individual skills utilized within the Navy in an effort to better understand some of the personable beliefs related to how the Navy may benefit from a CoP for programmers and developers. Listed below are the results of all questions:

(1) Question 1. Do you have certain skills that aren't utilized in your current Navy job? If so, what are those skills?

- There were three different responses from the group: yes, no or not applicable. One third of the group believed that their skills were utilized effectively. Another one third of the group stated that they were too novice in their current position to know if their current skill set(s) were properly utilized in their current position. One participant stated that the majority of their skills were utilized because they forced them to be utilized. The participant expressed concern that they had been told previously that developers did not exist in their current job, but from their experience developer skills have been a crucial part of their organization's operational success.

- Some of the skills that participants listed as being utilized in their current Navy job included: programming, software design and development, team and small group leadership, project management, organizing groups, rapidly executing programs, expanding collaboration opportunities, and in depth knowledge of institutional innovation. One participant expressed concern that even though they were extremely skilled and talented, their

junior rank affected their ability to be effective at utilizing those skills under their own cognizance.

(2) Question 2: As a programmer/developer, how do you keep your skills proficient?

- Participants provided a variety of answers to this question ranging from regular use and self-initiative to no effort because it would affect their family time. Some participants invested in personal projects to learn new skills, others chose to improve their skills through academic course work. The most common answer provided was continual projects and application of skills. Because these skills are highly perishable, they must be continuously utilized to maintain the level of expertise. One participant located conferences to attend in order to improve their operational prowess. Some of the participants were not programmers or developers, and therefore did not provide additional details for this question.

(3) Question 3: Do you think it is necessary to have skilled programmers/developers in the Active Duty Navy, or could Navy civilian employees or contractors better fill these jobs? Why?

- One hundred percent of participants agreed that it is both necessary and extremely important for the Navy to have active duty programmers and developers. One argument made was that active duty programmers and developers bring a different perspective that would not be present in the civilian or contractor culture, and that this was especially true when considering who will lead developer teams working on Navy projects. Active duty would allow for greater knowledge and greater ease in making possible changes quickly to networks. The participant continued to state that, "The technical leadership required to manage these teams of developers is a different skill set than required to manage other military fields. The developers (civilian, military or contractor) will not be as responsive to leaders who have not worked development projects. Leaders of developers need to have been developers or at the very least need to understand the constraints and challenges faced by the developers." [Anonymous]. Another participant made a similar argument related to this statement that sated everyone should learn some basic programming skills.

- Another participant agreed that it was 100% necessary to have active duty military programmers and developers in the Navy, but also stated that a blend was preferable. A blend would retain continuity through Navy civilians, but incorporate the creativity and fresh points of view from active duty military personnel. They further went on to state that a blend would allow for professional development opportunities for active duty personnel that they might not otherwise receive, and it may deepen their technical understanding of their job. Another great point brought up by a

participant, was that in the event of a furlough or contract lapse, active duty personnel could carry the load until issues were resolved, which has happened in previous years.

- Another participant supported the need for active duty programmers and developers, but stated that there needed to be a small cadre of professionals familiar with more technical backgrounds. They argued that this small cadre of programmers should be "familiar with the underlying mutable logical structures and code associated with naval and maritime systems who are also tasked directly with naval warfighting. While other groups can augment and support, if we are going to realize any degree of collective competence in naval cyber warfare, there will have to be some that are experts in the underlying, technical cyber terrain that is largely a composite of code and purpose-built computer hardware." [Anonymous]. Another participant supported this belief and added that they thought certain rates and restricted line officers should have these skills. In order to accomplish these tasks mentioned above, the participant felt that it would almost certainly have to be led by active duty personnel, because of a limited commercial or non-naval function for this type of expertise.

- Lastly, another argument for why there needs to be active duty Navy personnel with programming and developing skills, was because of their title 10 authorities, which civilians do not have. They also agreed that there should be a blend of active-duty personnel and civilians (for continuity), as well as contractors focused on expertise and surge capacity. In short, there is a need for all three sectors to work together toward accomplishing Navy goals and missions as related to programming and developing.

(4) Question 4: If the Navy paid you to maintain your programmer/developer skills, would that be an incentive to stay in the Navy and keep your skills proficient? Why?

- Fifty five percent of participants agreed that incentive pay would help retain Navy personnel as well as encourage them to keep their skills proficient. Twenty seven percent of participants said that incentive pay would encourage them personally to maintain their programmer or developer skills. Thirty three percent of participants said that it would not be an incentive for them personally. Of the responses that supported incentive pay, participants agreed that a decent level language pay would potentially close the gap between what industry pays versus the military. A common expressed concern among participants was their personal experiences in watching talented active duty members leave the Navy to work for industry because the pay was more attractive.

- While incentive pay may go a long way toward retaining active-duty personnel, another idea was to provide continual high quality training. Another suggestion was the need for both intrinsic and extrinsic motivators (no further details on what those motivators would be were given). One participant expressed concern that the skills of programmers and developers are not recognized in a meaningful way and are not formally supported by the Navy. They recommended that any shift in direction of recognition and support, pay or training, would fundamentally not only change their personal relationship with the Navy in a positive way, but also that of many other active duty service members.

- For those who said that incentive pay would not be an incentive to stay, one reason given was that they already receive plenty of incentives from the Navy, such as basic allowance for housing. For them, they were in the Navy due to a sense of service, and they keep their skills proficient in order to help the nation and do something important, not for incentive purposes. Another participant was in support of incentive pay, but said that given the number of years they already have invested in the Navy, that the financial benefits of retirement were more of an incentive than any bonuses associated to a certain skill set. They continued to state though that for Junior Officers or Enlisted personnel, that financial incentive might encourage them to stay until ten plus years, or even possibly a full 20 years of service.

(5) Question 5: How do you currently apply your programmer/developer skills to better yourself?

- Fifty percent of participants stated that they did apply their skills to better themselves, while the other half did not. Of those who did apply their skills to better themselves, most of the participants did so through building tools to solve their own problems, or working on small personal projects during their own time. Building tools for personal use allows one participant to be more self-sufficient, and feel empowered by knowing that they could build a program that can do nearly anything they wanted it to do.

- Another participant viewed programming and developing skills similar to that of any second or third verbal language, in that it is a skill they enjoy keeping current and they believed that it makes them a more valuable Naval Officer. Another participant dedicates their time to mentoring others who have the time to invest themselves in more actively larger-scale efforts, but also practices on small projects at home or outside of work. Lastly, one participant found benefits in automating a lot of the manpower intensive work, allowing them to dedicate more time to improve and develop their own personal skills.

(6) Question 6: How do you currently apply your programmer/developer skills to better the Navy?

- Seventy five percent of participants attend conferences, hackathons or internships as a means to apply their skills to better the Navy. Eight percent of participants work in technical fields where they must know how systems work, and consequently what is done to their individual components in order to find vulnerabilities. Furthermore, these participants must understand both the computer and software engineering components. While there is a small group of experienced and trained Naval Officers who work at such a technical level, the argument was made by one participant that the Navy needs Officers who can do technical work and lead teams of people to allow us to produce cyber capabilities.

- Another participant stated that they lead various cybersecurity-related efforts that tend to be experimental or innovative. Most of these efforts rely on a solid foundation of software development principles and application. Furthermore, participants participate in events where they social network and share knowledge.

(7) Question 7: How do you rate or evaluate the skill level of a programmer/developer?

- Some participants provided what they would rate their skill levels to be, which included advanced beginner, competent and intermediate. Other participants responded with how they personally evaluate other's skill level. One participant evaluated others based on conversations with each developer. Another participant evaluated the speed and how efficient the code both looked and ran. Other participants evaluated skills based on the combination of familiarity with various types of programming syntax, critical thinking ability, knowledge of how their programming/developing will affect other systems in a larger web of systems, and their ability to work in small teams.

(8) Question 8: How important do you think it is for programmers and developers to collaborate and network?

- Seventy five percent of the participants believed that networking and collaboration was extremely, very important, critical, and absolutely vital. They agreed that it was critical to the success of the Navy's formal cyber community. Given that there are so few programmers and developers within the active-duty ranks, the argument was made for the need of a tight community that can leverage different individuals experience and expertise. This community of programmers and developers could be used to help active duty personnel on a range of Navy platforms, both software and hardware, where they might not have the knowledge needed to

perform certain functions. Most participants agreed that networking and collaborating with other programmers and developers is a primary source for better practices, new techniques and code libraries.

(9) Question 9: Would you be interested in being part of a Navy Cyber Community of Practice for developers and programmers? Why?

- Seventy five percent of participants were interested in being part of a Navy CoP for programmers and developers. Some participants wanted to be a member in order to have a community they could reach out to when running into issues or questions. Other participants stated it would expose them to more challenges, and provide them and the Navy an awesome resource for leveraging expertise to answer questions. The CoP could help individuals learn new practices and develop professionally. One participant stated that the Navy needed a CoP to allow for greater knowledge and networking.

(10) Question 10: If you were part of a Navy Cyber Community of Practice for developers and programmers, what would be your level of contribution?

- One participant stated they would contribute more as a technical leader with a broad perspective on what the community is doing in cyber. While none of the participants felt that they would contribute specifically by means of coding, they did collectively agree that they could help connect people and help decompose a problem to make it easier to solve. Another participant suggested that they would contribute their knowledge and experience, time to answer questions, solve problems, work on projects, and mentor other programmers. Whereas another participant said they could bring a sense of operational relevance to the community.

(11) Question 11: As a potential Navy Cyber Community of Practice member, how would the community be of value to you as a member?

- Most participants stated that their answer to this question was the same as stated in question 11. Other participants elaborated to share that they would benefit from a CoP by getting answers to their questions, help with solving problems, and mentorship. Another member stated this CoP would be of value to them due to the ability to form groups to solve problems ad hoc, as well as way to stay abreast of other individual's accomplishments and efforts. A CoP as stated by several participants would be of additional value because of the ability to rapidly share ideas and experiences, as well as reach out to find assistance and talent needed for certain cyber projects.

(12) Question 12: If the Navy did have a Community of Practice for developers and programmers, how would you envision this to look or operate (ex: online community, website, face-to-face interactions)?

- Seventy five percent of participants supported face-to-face interactions and events. Thirty three percent of participants supported an online community. Sixty percent of participants supported a combination and balance of face-to-face interactions and events coupled with an online community. Participants stated that face-to-face events, such as HACKtheSKY, provided a venue for civilians to think about military problems, as well as military members a venue to interact with more advanced skilled programmers and programmers and sharpen their skills or develop new skills based on their networking and interactions.

- One participant suggested face-to-face interactions on a "monthly-ish" schedule, hosted by various sub-groups representing various technical and functional areas. Another participant suggested the most compelling interaction would be those events hosted by local chapters, which would enable more frequent face-to-face interactions. While another participant suggested a Cyber Task Force face-to-face interaction, where groups participate in cyber tabletop discussions for new equipment, as well as cyber exercises that allow access to actual systems.

- In regards to an online community, participants wanted an online community that provided the ability to ask questions and share work. They further suggested that a Navy developer stack exchange would be a great feature. They also believed that the online community should be both military (active-duty and reservists) and civilians. As argued before, civilians bring long term perspective and continuity, and the military brings the practical warfighting perspective. One participant in support of a primarily online community expressed interest in a secure and authenticated online community. Another supporter of an online community suggested that there should be challenges and face-to-face events that included a point based ranking system much like an online game.

- Several participants referenced Stack Overflow as one of the best online communities for programmers and developers. What they liked about Stack Overflow was that they claimed it provided solutions to coding and other issues that allow a forum for help and assistance. They also found the website valuable for handling coding segments that they found challenging, but were solvable with the help and review of the code by other peers. Most importantly, Stack Overflow, as expressed by participants, was seen as a one-stop shop for most of their answers to anything technology related.

(13) Question 13: Do you think a Community of Practice for developers and programmers would serve a purpose and benefit for the Navy?

- Eighty eight percent of participants said the Navy would benefit, and one participant said it would depend on the implementation. The one participant who was concerned with implementation stated that, "implementation could go from being a voluntary effective tool for knowledge sharing, networking and mentoring to mandatory trainings that have to be complete" [Anonymous]. For the rest of the participants who thought a CoP would serve a purpose and benefit for the Navy their reasons included: exposure to new problems, global impact, potentially save lives, connect people in order to help each other solve problems, help approval and testing processes, assist in development of community projects, professional development, share knowledge, and further develop existing talent(s). A more technical case made by one participant, was that a CoP would allow the Navy to, "keep pace with the development of new threat capabilities, to upgrade our existing capabilities, or to develop altogether new and novel capabilities at a pace that many approximate or surpass that of threat actors" [Anonymous].

(14) Question 14: If you could maintain a 20-year career in the Navy as a dedicated Navy cyber programmer or developer, would that interest you? Why?

- Forty three percent of participants said that a career as a dedicated Navy cyber programmer or developer would be of interest to them, 57% said it would not be of interest, but that they saw the benefit, and 43% said it would not be of interest at all. One interested participant would be interested so long the career provided operational experience reverent to the projects one would work on, in addition to a monetary incentive close to that of what industry provides. Those participants who were not interested stated it was due to the fact that they desire to have greater leadership experience instead of a technical career path. While not everyone would be interested, all participants did agree that it was important to have career pipelines for programmers and developers.

(15) Question 15: If you think a cross-Community of Practice is valuable for the Navy, what sort of accommodations would the Navy need to make in order for you to participate given your current and next expected billet or assignment?

- Some accommodations recommended by participants included setting up an online community, funded travel to community related events, funded training, conference participation credit, increased promotion bonuses, prizes for winning competitions, and the ability to work real-world problems and systems. Some participants argued that active duty members

need time to develop and work on their programming and developing skills without sacrificing future advancement opportunities. They further stated that the Navy needs, “to make programming and development the main job, not just a job you do on the side” [Anonymous]. Another participant recommended that the Navy should allow the time and ability to build, maintain, and grow teams over time.

- One participant recommended that multiple locations should be considered for meeting, including fleet concentrated areas. This would allow for easy travel for more military personnel. One suggestion was one event on the east coast and another on the west coast, with the ability to possibly offer a virtual teleconference option for those who could not make the travel. This would allow multiple abilities and avenues for max military participation.

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APPENDIX C. CIVILIAN RESEARCH INTERVIEW QUESTIONNAIRE

The civilian research interview questionnaire consisted of 15 questions. Four participants provided feedback for this survey. The intent of this survey was to gather information about how individuals keep their skills proficient, if they were prior military, and if so whether or not they utilized their programmer or developer skills while in the military, their experience with CoPs, and specifically their thoughts on a Navy CoP for programmers and developers. Listed below are the results of all questions:

(1) Question 1: Prior to your current job, did you ever serve in the military? If so, what branch, and what was your rate/rank/job?

- Seventy five percent of participants had prior military experience. One participant served 26 years total active duty as an officer in both the United States Marine Corps and the United States Air Force (13 years in each respective service). The other two participants served six and nine and a half years respectively enlisted in the Navy, in the Cryptologic Technician Networks rating.

(2) Question 2: While in the military, did you perform programmer/developer duties? If so, to what extent?

- The prior military officer did not perform programming or developer duties while serving in the military. One of the prior enlisted participants served four of their six years as a programmer and developer. The participant built tools that ran on a sensor grid, wrote helper scripts for forensics personnel, and later wrote stuff to warehouse and access loads of data. The other prior enlisted participant helped build and maintain a custom sensor grid for their organization utilizing various programming languages. Additionally, that participant held various job titles including: Forensics Lab Manager, Reverse Engineer of Malware, Network Forensics and Packet Capture Subject Matter Expert.

(3) Question 3: What did you like most about your work in the military? What did you like least?

- What the prior military officer liked most about their work in the military was their time in the United States Marine Corps as a Company Grade Officer, and being on the flight line making airplanes meet the flight schedule. What the participant liked most about being in the Air Force was the time spent mentoring young Company Grade Officers and filling the

position of a systems engineer. The participant did not share what they liked least about their time in the military.

- What one prior enlisted participant liked most about their job in the Navy was the fact that they were getting paid to code with no previous academic credentials or background. What they liked least was the "utter lack of commitment to meaningful success" [Anonymous]. Additionally, they disliked the Enlisted evaluation process. They felt that the evaluation process was more focused on "check boxes and numbers vice incremental progress toward a defined goal [on] overall improvement. Development is a continuous process where the amount of work does not necessarily immediately translate to a number" [Anonymous]. While this Sailor was a highly rated performer at both Commands they served at, they often found themselves performing under the mindset that is was better do work that would "enable" and "improve" processes instead of quantitative measurable work.

- What the other prior enlisted participant liked the most about their job in the Navy was the mission and the ability to make a difference. What they liked least was the "bureaucracy, red tape, and the lack of understanding" [Anonymous]. For them personally, they were often frustrated that their leaders did not understand or grasp the technical aspect of their job, therefore often leaders squashed certain projects or ideas. This frustrated the participant, because a few years later after presenting an idea or project to a leader who later squashed it, they would see a private company making millions off similar thoughts and ideas.

(4) Question 4: What led you to your current job?

- The prior military officer participant retired from the Air Force, and became a professor, since teaching was one of their long-term desires. Another participant was provided the opportunity to work at the intersection of legal, data science and coding fields.

- While still enlisted in the Navy, one participant was working on a project with his current civilian boss. When that boss caught wind that the participant was getting out of the Navy, the boss contacted the participant and hired them. The other participant still does the same job(s) as when they were enlisted in the Navy, but now they get paid what they think they deserve.

(5) Question 5: As a programmer/developer, how do you keep your skills proficient?

- To keep their current programming and developing skills proficient, all participants claimed to either self-teach or learn through an academic

setting. One individual self-teaches at work by reviewing internal documentation and studying other entities code changes.

- One prior enlisted participant is constantly reading technical books related to programming and developing. They are on multiple mailing lists, and they make an effort to read all applicable materials that will help further their knowledge and skills. This participant is also a member of a professional group that openly shares information. This participant is rather self-motivated and actively seeks out people who are more skilled in the area in order to collaborate. The other prior enlisted participant claims that they constantly work with like-minded individuals and thinking outside of the box in order to complete projects.

(6) Question 6: How do you rate or evaluate the skill level of a programmer/developer?

- Two participants claimed to be a novice, while the other two did not identify with a specific Dreyfus skill acquisition. Instead, they commented that their skills are "based on [the] ability to produce code with good architecture split into logical bits for code review instead of one giant blob" [Anonymous]. One novice individual stated that they, "always viewed programming as a means to an end, just like a computer is just a tool. I focus more on the critical thinking and less on the specific tool used," [Anonymous]. Another self-acclaimed novice commented that even though they claim to be a novice other individuals view them as more skilled than they personally view themselves.

- One prior enlisted participant rates and evaluates others' skill levels based on their ability to problem solve and deliver. They personally have no faith in tests or questions, as they tend to boil down to trivia. They value how an individual uses what tools to tackle a problem as well as their ability to work practical examples. Often, the participant has hired individuals that failed their interview coding challenge, but demonstrated solid logical approaches to problems presented within an interview.

(7) Question 7: How important do you think it is for programmers and developers to collaborate and network?

- All participants agreed that it is very important for programmers and developers to collaborate and network. One participant has personally witnessed peers fail in their field when they were moved into an environment where their work was audited or they worked as part of a team. Therefore, the participant takes value in collaboration and team building in order to expose oneself to their flaws and improve skills. One participant believed that if more people would talk, issues would resolve themselves better and faster. Additionally, they believed that at any given

time there are similar projects being worked on by various individuals who do not know about the others' work, but if they did they could collaborate and save time on a project. Another participant made the case that open source is a huge plus, and that networking and collaboration may help break the proprietary paradigm [Anonymous].

(8) Question 8: What has or would motivate you to join a Community of Practice?

- All participants had similar responses to this question. They all agreed that what would motivate them would include: the ability to lean on those that really get it, support in a non-intrusive way, mentoring, the access to people with different experiences and areas of expertise, and the inherent interest that comes with access to learn from more experienced and skilled individuals.

(9) Question 9: How do you think you would benefit and/or contribute to a Community or Practice of programmers and developers?

- One participant said they would certainly benefit more than they would contribute at first, but that they could contribute due to their wiser perspective perhaps. The other participants claimed they would benefit from seeing how others break down and tackle problems and the social collaboration aspect. They claimed that a CoP would help expand their professional network and enable access to jobs they might not otherwise have. They also claimed they could contribute by sharing personal experience on how they were able to learn to code with no formal academic background.

- Another participant believes that with a CoP, they could globally solve issues that are currently be dealt with. They encouraged the benefits of opening community participation to junior personnel in order to take advantage of their fresh ideas. They also shared a desire for the Navy to host their own GitHub lab or server to maintain this type of collaboration.

(10) Question 10: Do you think it is necessary to have skilled programmers/developers in the Navy? Why?

- All participants agreed that it is necessary to have skilled programmers and developers in the Navy. One participant gave two reasons as to why they thought the Navy needs Sailors who can actually program, "1. It is good for government to have organic capability to do things on its own and not be beholden to contractors. 2. We need educated Officers who understand how to roll their sleeves up and do it, in order to better administer $M [million dollar] contracts as the government oversight on large complicated IT projects," [Anonymous].

- One participant believes that Navy personnel know better than any outsider the data, domain and challenges that the Navy faces. Therefore, they believed that the Navy could resolve many cyber issues with the establishment of a CoP for programmers and developers, and do so without any red tape or restrictions.

- Another participant said that it was very important because, "The world is rapidly moving to everything cyber and we must make sure to keep up and be on the forefront. Cyber vulnerabilities in particular can be extremely costly and having the skilled developers to build and support a multi-layer defense is therefore critical," [Anonymous]. Another participant added that they have witnessed the benefits from actually doing the job. They argued that the Navy does different work than a lot of the rest of the world, in that they have different expectations and requirements. Therefore, naturally there should be military professionals actually creating applicable solutions.

(11) Question 11: Do you think a Community of Practice for developers and programmers would serve a purpose and benefit for the Navy? Why?

- All participants agreed that a CoP for developers and programmers would "possibly" serve a purpose or benefit for the Navy. One participant suggested that there would have to be boundaries placed on the CoP in order for it to be productive in generating something of relevance to the Navy. They went on to state that keeping cyber skills sharp would produce a cadre of cyber warriors, but boundaries may need to be put into place to harness the enthusiasm and channel it toward mission support. They also believed that while CoPs should be something fun and constructive with possible incentives to compete against other teams and win cash prizes, the goal of events should ultimately be to support Navy mission(s). If boundaries weren't put in place, the possibility of a CoP becoming a "shadow organization" that works in multiple directions will counter where the overall mission is headed. Additionally, one participant believed that due to the Navy's access to many datasets, that the Navy could help create more data science and analytics.

- Another participant suggested that the Navy might benefit from learning circles, and how they help motivate individuals, especially those who possibly doubt their skill levels and are apt to failing without mentorship. Another participant backed this up, by stating that they have seen a lot of people in their situation, where they are smart individuals but have essentially no technical talent, but they are expected to perform a role as a programmer and developer. Therefore, they are left to explore on their own and become self-taught programmers or developers. The purpose of a Navy CoP for programmers and developers would be the sharing aspect.

In this participant's experience, open collaboration has always helped them. More often than not many problems they were working on had already been solved, but due to the lack of collaboration with other programmers and developers they were not aware of the progress of individuals had already made.

- One participant shared a personal experience about a colleague who was trying to build a new thing. This colleague emailed the participant. The participant replied back with a link to an already completed project that related to what the colleague was trying to build. This collaboration saved the colleague months of work, and as a result the colleague ended up with a better solution then having started from scratch. The participant further stated that one reason the Navy community needs collaboration is due to its relatively small size yet wide distribution.

(12) Question 12: In your experience, what are some possible inhibitors from collaboration with the government and civilian sections, related to programming and developing?

- One participant stated that the industry is profit-driven and pays to have a programming source or outsources it. Whereas the government acquires programming expertise in order to accomplish the mission of integrating tools for mission use. They further went on to state that they did not think there was much potential for true collaboration due to the DOD acquisition program.

- Another issue raised by participants is bridging the gap on trust-in-the-government that currently exists in the technology industry. According to the participant, the technology culture is very anti-authority and contrarian, and that the usual appeals of a CoP might be difficult. Another issue mentioned was the constraints put on the Navy, and often called "red tape," in addition to a lack of leadership understanding cyber issues and tools, egos, and archaic thinking.

- One participant believed that Sailors move around too often, between both jobs and duty stations. They believe that this constant change negatively impacts a Sailors ability to become an expert in their practice. They believe that introductory schools, often referred to in the Navy as "A" schools, do not produce expert programmers or developers, instead they teach them basic skills and then it is upon that individual to learn more if they desire to excel and further their skills. But as previously mentioned, when a Sailor is constantly changing their job or moving to a new location, this does not afford them the time to improve on their skills unless they do it on their own time outside of working hours.

(13) Question 13: Would you be interested in being part of a Navy Cyber Community of Practice for developers and programmers, and what would be your level of contribution to the community? Explain.

- Seventy-five of participants would be interested in being part of a Navy CoP for programmers and developers. One participant stated they would not be interested given their domain of interest is not so much cyber, but more focused on data science, and they did not feel they would have much to contribute. The other participants would like to be members, and would love to help in any way they could, skills permitting. They believe in the mission of the Navy and are eager to help in any way possible. One participant even offered that as a member of the CoP, and given his current job location, that their command could create scenarios that needed to be worked on at a future hackathon or similar event.

(14) Question 14: As a potential Navy Cyber Community of Practice member, how would the community be of value to you as a member?

- One participant said they would benefit from the awareness of issues that were relevant and timely to the community. Another participant said it would be great to learn and teach others, and further their personal understanding of the Navy, as well as networking with like-minded people. Another participant believes that they have operational knowledge and lots of ideas, but little time to complete them, therefore a forum would help them with voicing their thoughts and concerns and getting assistance from other members.

(15) Question 15: If the Navy did have a Community of Practice for developers and programmers, how would you envision this to look or operate (ex: online community, website, face-to-face interactions)?

- All participants suggested an online community given the far-flung nature of the Navy, but to also include face-to-face interactions. One participant recommended that an online community should resemble the features found on Slack or Google group. They also recommended that the online community persistent and asynchronous. Additionally, participants believed that face-to-face interactions would help in building personal bonds between individuals. Recommendations were made for virtual teleconferences and future hackathons. One participant questioned the classification level of the community. One participant recommended a open platform similar to how Git operates to develop the linux kernel. They also recommended selecting several collaboration sites that are currently hosted to the public, and allowing members to vote on their preferred platform.

- One warning that one participant addressed was the Navy's tendency to get over-indulged in measurable requirements. They expressed concern that the Navy actively engaged immediately, which to the participant is not only exhausting, but discourages them to be a member of a team with leadership that treats them as a tool and not as a person.

APPENDIX D. POST-HACKATHON SURVEY

The post-hackathon survey consisted of 14 questions. Thirteen participants provided feedback for this survey. The intent of this survey was to gather feedback and recommendations on participant's experience at HACKtheSKY. Listed below are the results of all questions:

(1) Question 1: Did you attend all three days of the hackathon?

- Seventy seven percent of participants attended all three days of the hackathon (Friday through Sunday).

(2) Question 2: How did you hear about the hackathon?

- Sixty two percent of participants heard about the hackathon from one of the HACKtheSKY event planners. Fifteen percent heard about the hackathon by word of mouth, 15% through social media, and 8% through an existing CoP that they were members of.

(3) Question 3: Why did you attend the hackathon?

- The most common answers provided for why participants attended was to meet like-minded individuals and network, increase knowledge, and improve programmer and developer skills. One participant thought the event looked like a great way to give back to their country since it was military related. Another participant initially attended under the pretense that they were going to be a mentor and/or judge, and instead ended up mentoring and participating in the event.

- Other participants viewed the hackathon as an opportunity to play with new frameworks and networks across various Communities of Interest. Some participants attended because their Command paid for their travel. One participant attended because their boss told them to. One participant attended because they believed in establishing a community of developers within the Navy, as well as working with industry to gain insight into good and bad practices.

(4) Question 4: Did the hackathon meet your expectations? Please explain.

- Eighty five percent of participants did believe that the hackathon met their expectations. Fifteen percent of participants believed that the hackathon did not meet their expectations. Some participants exclaimed that the

hackathon exceeded their expectations because of the networking aspects, as well as the fact that they were surprised by how much they were able to contribute. Some participants thought that they would not be able to contribute due to their lack of familiarity with the drone infrastructure, but they proved themselves wrong.

- Participants were impressed with all the "great minds working in teams," and that overall they learned more than expected from different people on their team as well as other groups participating in the hackathon. One participant stated that they were pleased with the extensive networking outside and inside of the Department of Navy, as well as the exposure to all the methods and practical difficulties of both the workshop and hackathon. Several participants commented on the "cool location" in regards to where the hackathon was located and hosted in San Francisco.

- For one participant, this was not their first hackathon. A matter of fact they had been to several hackathons, but they stated that this was the best-organized one they had attended. They appreciated the clearly outlined problems. One recommendation they had was that the code be shared further in advance instead of the day of the event. They believed that if they had had the code prior to attending the event, then they could have developed a better code to solve the problem.

- One participant recommended that the event would have been better if there were a fourth day in order for hackers and design thinkers to work together on a team in order to better implement stronger solutions for presentation. Several participants had hoped that there would have been more adversary focused problem sets where they would "break things," as opposed to cybersecurity problem sets and "creating fixes." While those expectations were not met for some participants, they did benefit from coding and developing "Proof of Concept" code solutions.

(5) Question 5: What did you learn during the hackathon?

- For most participants this was their first time working with the drone Remote Operating System. For some participants this was their first time working with service members, and it gave them a better understanding about how the cyber community is structured within the military. One participant stated that they were surprised with how many people could code within the Navy than they initially thought. They also learned that 'we all work in silos and we need to be working across organizations, because there are [more] coders than I thought, but not enough to cover all [of] the Navy's problems" [Anonymous]. Other participants discovered through attending the hackathon and working on small teams that they needed to enhance their coding skills and exposure to different programming languages.

- For the participants that attended the Design Workshop, they learned more about facilitation, design thinking skills, and human based design planning methods. One participant realized that they needed to incorporate and train on more design methodologies, as they would greatly benefit any project a team is working on.

(6) Question 6: What did you most/least like about the hackathon?

- Participants stated that meeting other participants was the best part of the hackathon. One civilian participant liked the fact that they were able to meet military individuals working on cyber issues. One participant who just recently joined the reserves was most excited about discovering that they would apply their programming skills in the Navy, as they had fears that they would not be able to apply them fully in the Navy. This hackathon showed them that there were more opportunities to use their programming skills than initially thought when they first joined. Therefore, they felt a new sense of excitement about joining the Navy.

- Other participants enjoyed the diversity of both participants and problem sets presented for both the hackathon and design workshop. Participants who attended the design workshop thought that the design methodology phase was "enlightening."

- One participant stated that what they liked least was the distance they had to travel each day, due to the location of the event and where they lived locally. One participant wished that one of the hackathon prompts (multicast) were more challenging. Other participants wished they had had more time to socialize with their teams. They felt that they were so focused on their specific problem, that they did not take the time to talk to other individuals as much as they would have liked throughout the weekend. Other feedback regarding things participant least liked included: too early of a start time on Saturday and Sunday, better snacks and drinks, more information about team formation strategies, and lack of focus and preparation on Friday's baseline briefs.

(7) Question 7: What recommendations would you make for future hackathons?

- The number one recommendation was a hackathon that focused on other real-world scenarios and issues. One recommendation was defensive cyber operations. Other technical recommendations included: working out technical setup kinks, increased standard tool use (e.x. GitHub), set up virtual boxes in order to allow people to interact with running code, clear and upfront brief on problem sets, more lead time on scope of objectives and challenges, and earlier distribution of code base to participants prior to hackathon.

- Non-technical recommendations included: never running out of coffee, including more civilians at the event, explain to participants what to expect from attending their first hackathon, incorporate hackers and design thinkers onto one team as opposed to two separate events. Additionally, regarding the two separate events, one participant recommended that the team formation and facilitation process for the design workshop should be better organized next time and separated from the hackathon. Lastly, while participants liked the venue, they did not like the chairs.

(8) Question 8: If there were another Navy Cyber Community of Practice hackathon, would you attend? Why?

- Ninety two percent of participants said they would attend another hackathon. One participant said they would not attend, because they were not a programmer or programmer, and were just there for the design workshop. Participants said they would attend another one given their positive experiences from this recent event. They would also attend another one for the same reasons they attended this one: social networking and enhancing coding skills.

- Other reasons participants would attend another hackathon included: to see "state of the art" technology, the importance to continue building these type of relationships and share information, networking, refresh coding skills, cross Navy idea pollination, broaden the experience of developers and give them viewpoints on problem sets never before considered by most, maintenance of skill sets, and personal growth. As one participant best stated, "It is also a good opportunity to refresh coding skills. It is like any other language proficiency. If you don't use it, it goes away" [Anonymous]. Another participant believed that both the hackathon and CoP concept were valid and they want to see both evolve from this first event.

- One participant said they would attend, because they had the opportunity to meet like-minded individuals who were working on similar projects as them within their civilian organization. Through the weekend interaction and meet up, they were able to overcome issues they both had on a similar project. They were also able to share research and assist each other on their current civilian job projects.

(9) Question 9: Were you on a predetermined team, or a team of random individuals? Please explain your experience in regards to interactions and collaboration with team members.

- Seventy five percent of participants were on a team made of random individuals and 25% were on a pre-determined team, this includes both hackathon and design workshop participants. Each participant had

different experiences regarding how they met their teammates and conducted collaboration. One participant met a group of military veterans during Friday night's social, after they started socializing with the veterans they were then asked to join their team. The participant was the only industry member on the team. They worked well together and enjoyed their experience so much that they continue to communicate post-hackathon. Participants who were on a team of both military and industry participants appreciated the range of perspectives and skills gained from collaboration.

- Some participants who were on a random team enjoyed the opportunity to self select their teammates. It allowed them to find a good balance of personalities to work with. One team was formed from conversations held at Friday night's social. What they did not realize till Saturday morning after continued conversations was they were mostly active duty military. This group formed a team and collaborated very effectively, split up tasks and accomplished them quickly. They reported that they all came together and merged their work into one product. One participant from this team stated that "everyone had a great attitude and equal say in each aspect of the product produced" [Anonymous]. Even outside of the hackathon and after hours they shared meals and drinks.

- One participant was on a pre-determined team that consisted of them and a teammate from their industry job. They were more interested in focusing on the problem instead of learning to work and collaborate with a group of random people in a short period of time. From previous experience at other hackathons, they have had mixed results from working on random teams.

- One design workshop participant was not able to attend the Friday night social and therefore was randomly thrown onto a team. The difficulty they experienced was the lack of time that they had to get to know one another. They felt that when you do not know the people on your team ahead of time, that the "forming, storming and norming" stages of team development get accelerated or skipped, which can become a barrier to team progress and success. One recommendation was to share bios possibly for all participants in order to make teammates familiar in the preceding days or weeks prior to an event in order to build trust. They also recommended that event planners should put more time in to acknowledging new members, welcoming them, and providing guidance on how to move forward with projects.

(10) Question 10: Did you expand your social network due to your attendance at the hackathon?

- All participants stated that they expanded their social network due to attending HACKtheSKY. One participant reported connecting with over a dozen new individuals. Another participant reported that they have remained in touch with teammates and other participants via Slack, email and Facebook. For some of the participants they had only met attendees once or twice before, or only via email, so attending this event was a great way for them to put a name to face and further interact, converse, collaborate, and brainstorm ideas. Participants commented that the social networking that took place was one of the most important pieces of the weekend.

(11) Question 11: Did you find the hackathon to be of value? How and why?

- All participants believed the hackathon to be of value. Some reasons provided that participants found it to be of value included: tangible results, expanding human networks, knowledge gained, reviving rusty coding skills, and free shirts and stickers. One participant said that the hackathon "opened my eyes to the complexity of our system design and the passion of many individuals. I think meeting everyone on my team and the methods taught during the workshop will help me lead future efforts to produce innovate solutions to our toughest problems" [Anonymous]. Another participant shared that they thought this event was a great start to developing a CoP, and "that the more we can focus on tackling big opportunities and moving into execution/follow-on, the more compelling these events will become" [Anonymous].

(12) Question 12: Do you think the Navy would benefit from future hackathons, if so, how frequent do you think they should be? (Ex: Annual, bi-annual, quarterly)

- Forty six percent of participants recommended future hackathons being hosted bi-annually (twice a year), 31% voted for quarterly events, and 23% voted for a future hackathon to be hosted annually. Some participants recommended a combination of quarterly events, with at least two of those events being a hackathon. Several participants stated that a quarterly hackathon might be too often and annually might be too infrequent and that bi or semiannually would be the sweet spot. Participants also suggested that frequency should depend on location, and recommended that hackathons be geographically distributed.

- One participant recommended trying quarterly hackathons if the interest persisted and if it helped in keeping developing ties within the local

community and industry. Another participant stated that if the hackathon was in the same city every time, then they would recommend it to be bi-annual or annually, but if the event moved from city to city that they could occur more frequently. One participant suggested that an annual hackathon would allow for enough time for both preparation and developed interest.

- One participant stated that a future hackathon would be "hugely beneficial both socially and to develop a community within the DOD" [Anonymous]. They also recommended that a hackathon be held quarterly or bi-annually in order to provide ample opportunity for personnel to attend given busy schedules. Another participant acknowledge the importance of a regular drum beat, but recommended that future hackathons should be centered on opportunities rather than a specific schedule. They recommended to "let the demand fuel the events more than a schedule. For team hosting events, bi-annual was feasible, quarterly a stretch, and annual would work, but may not be frequent enough to catalyze the community" [Anonymous].

(13) Question 13: Do you think the same effects could have been achieved through other means than a face-to-face hackathon? Please explain

- Fifty eight percent of participants stated that the same effects could not be achieved through other means than a face-to-face hackathon. Thirty-six percent of participants thought it might be possible or there were perhaps other ways, and 6% thought the same effects could have been achieved in other means. Most participants who believed that the face-to-face hackathon effects could not have been achieved otherwise were mainly due to the social networking aspect of the weekend. They echoed that this was a vital part of the event. They believed that putting faces with names and exchanging business cards was the most beneficial part of the events.

- Other participants did not believe the same effects could be achieved, because there is not a replacement for rapid development, face-to-face interactions are vitally important, these events build trust, and working in person produces better ideas and focused work for a period of time, just to name a few. One participant said that any other means of an event would not have produced the same 'fun' feeling that HACKtheSKY did. For this participant "seeing like-minded folks in a room crashing on a problem is awesome" [Anonymous].

- One participant believed that absolutely not the same affects could have been achieved through any other means than a face-to-face hackathon. Their argument was that "the face-to-face interactions, opportunity for formal and informal team-building, serendipitous interactions/exchanges, and the sense of urgency and focus that comes from being in a socially engaging, team-oriented environment is without parallel. This could not be accomplished without something like this tangible event" [Anonymous].

- Another participant recommended doing another event a month of two after the initial hackathon to ensure "the camaraderie and trust are already established by most participants" [Anonymous]. They also added that face-to-face hackathons should give a lesson on distance collaboration.

- Another participant recommended that doing a hybrid event would possibly produce the same affects. Their recommendation included doing a live event, where some parts of it were recorded, such as the opening description of the challenges. This video could then be posted to YouTube. They further recommended coupling the event with a link to MMOWGLI, Slack and GitHub, as a way to open it to the rest of the world for participation.

(14) Question 14: Please include any additional feedback, recommendations, or thoughts and concerns regarding your participation during the hackathon.

- Some additional feedback provided by participants included: great facility but parking was not ideal, time well spent, connect the design thinking team with hackathon programmers and developers, and keep doing the great work. One participant recommended the use of standard tools such as GitHub. They believed that by using standard tools, primarily GitHub due to its popular use in the technology industry, events would run more efficiently and smoother.

- One participant reiterated the necessity to "get private sector folks interested in this kind of stuff and try hosting such hackathons more frequently" [Anonymous]. They further recommended that to the extent people request being placed onto a random team, that event planners should try to match industry and military members together. This would facilitate the private-public exchange and connections. The participant also recommended that it would be great if there were a website dedicated to team learning coupled with regular in-person meetups. The purpose of these interfaces and collaboration opportunities would be to "help folks ramp up on various coding styles/frameworks and grow in other's presence" [Anonymous].

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